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PROCESSING THE DATA FROM THE OGO-III GEGENSCHEIN PHOTOMETRY EXPERIMENT

JOHN J. QUANN

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GODDARD SPACE FLIGHT CENTER
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CONTENTS

1. INTRODUCTION

OGO-B SPACECRAFT

The Gegenschein Photometry Experiment is one of 20 geophysical experiments aboard the OGO-B spacecraft. These experiments are intended to provide information for gaining a better understanding of the earth and earth-sun relationships.

OGO-B (Figure 1-1) was launched from the Atlantic Missile Range into an eccentric orbit of about 31 degrees inclination. The spacecraft has a nominal perigee of 150 nautical miles, a nominal apogee of 60,000 miles, and an orbit period of 48.5 hours. The orbit path traverses the Van Allen radiation belts twice each orbit; it allows the spacecraft to make geophysical measurements from regions near the earth to those in cis lunar space.

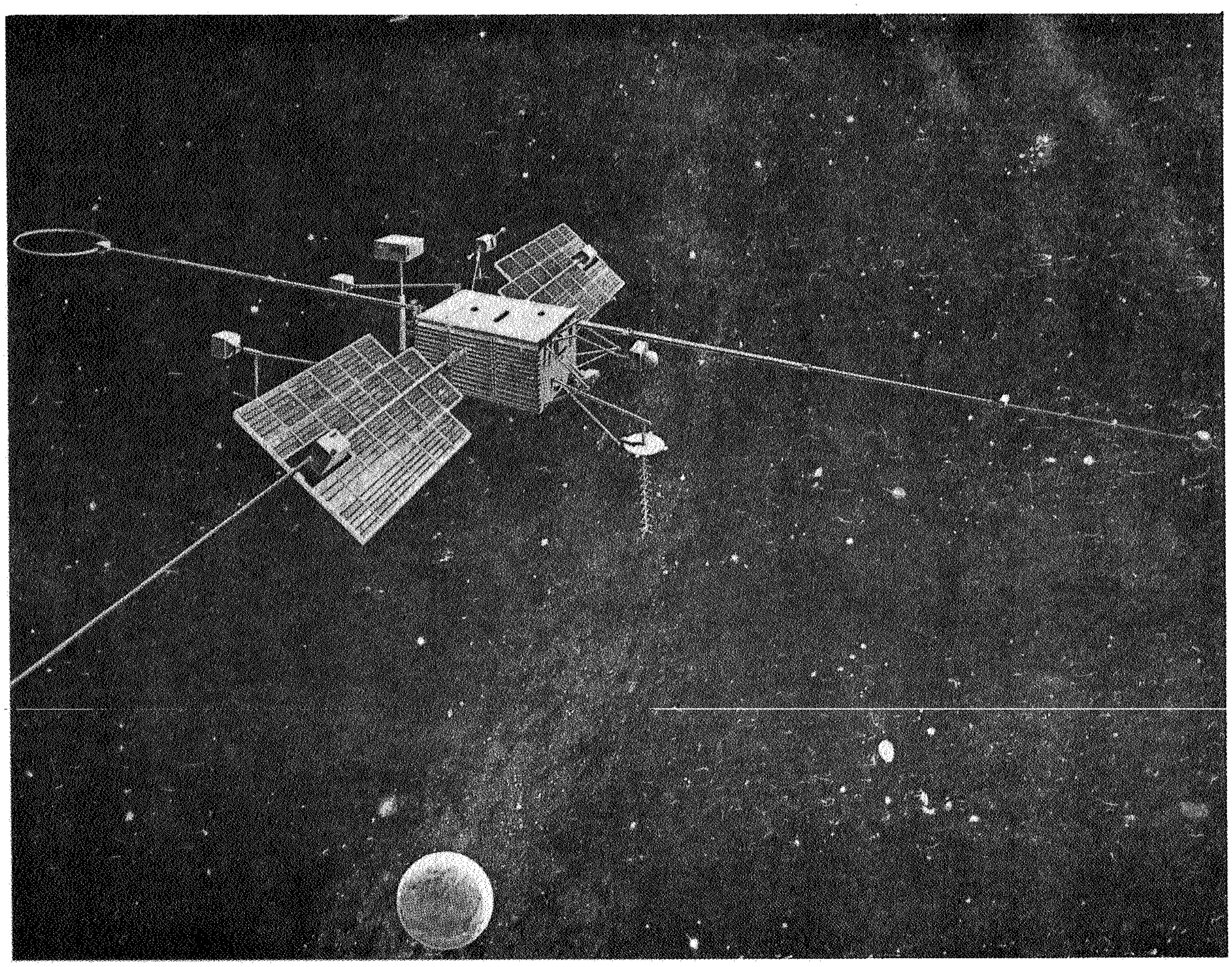


Figure 1-1. OGO-B Spacecraft

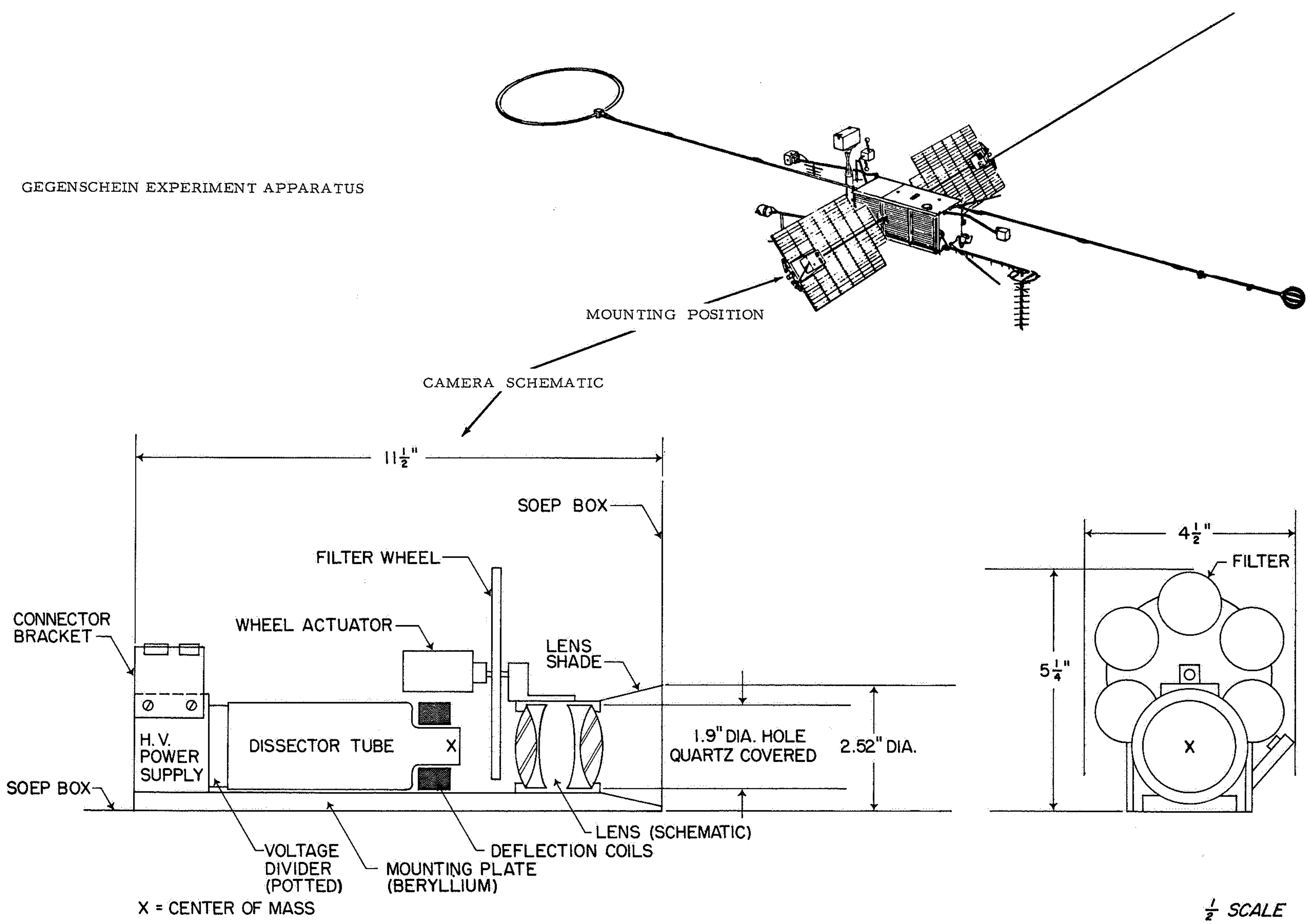


Figure 1-2. Gegenschein Experiment Apparatus

GEGENSCHEIN PHOTOMETRY EXPERIMENT

The gegenschein (or counterglow) is a faint, elliptical patch of light that is visible in the night sky opposite the sun. It is thought to be a reflection of sunlight by meteoric matter in space whose origin is associated with the zodiacal light.

OBJECTIVES

The primary objective of the experiment is to determine the location of the gegenschein. Other objectives are to determine the following:

- The shape and structure of the gegenschein, such as whether it is created by gas or dust.
- Its spectral properties.
- Variations in the shape, composition, and magnitude of the gegenschein.

APPARATUS

The experiment apparatus consists of a high photometric precision camera aimed in the anti-solar direction. As shown in Figure 1-2, the camera is part of a Solar Orbital Experiment Package (SOEP) mounted on one of the two solar arrays (SOEP 2) appended to the spacecraft body. The camera has a 2-inch (diameter) lens that projects an area of the sky 11° by 16° onto the face of an image dissector photomultiplier. Different spectral images are obtained through the use of a filter wheel containing five colored filters (the sixth filter wheel position contains a radioactive source at one corner and is used for calibration purposes).

DATA GENERATION

Each experiment cycle, the camera generates six images, one for each filter wheel position, plus the calibration. One set of pictures is generated approximately every 68 minutes at the 1K bit rate. Data is also generated at the 8K bit rate; at this rate, eight images are taken at each filter position for a total of 48 pictures per set.

Each image is in the form of a raster-type scan of an 11° by 16° sky area. It can be visualized as a rectangular array of 704 elements arranged in 22 lines of 32 elements each; an element depicts a sky area about $1/2^{\circ}$ by $1/2^{\circ}$. (See Figure 1-3.) The experiment apparatus transmits an intensity value for each element that can range from a value of 0 through 32,000.

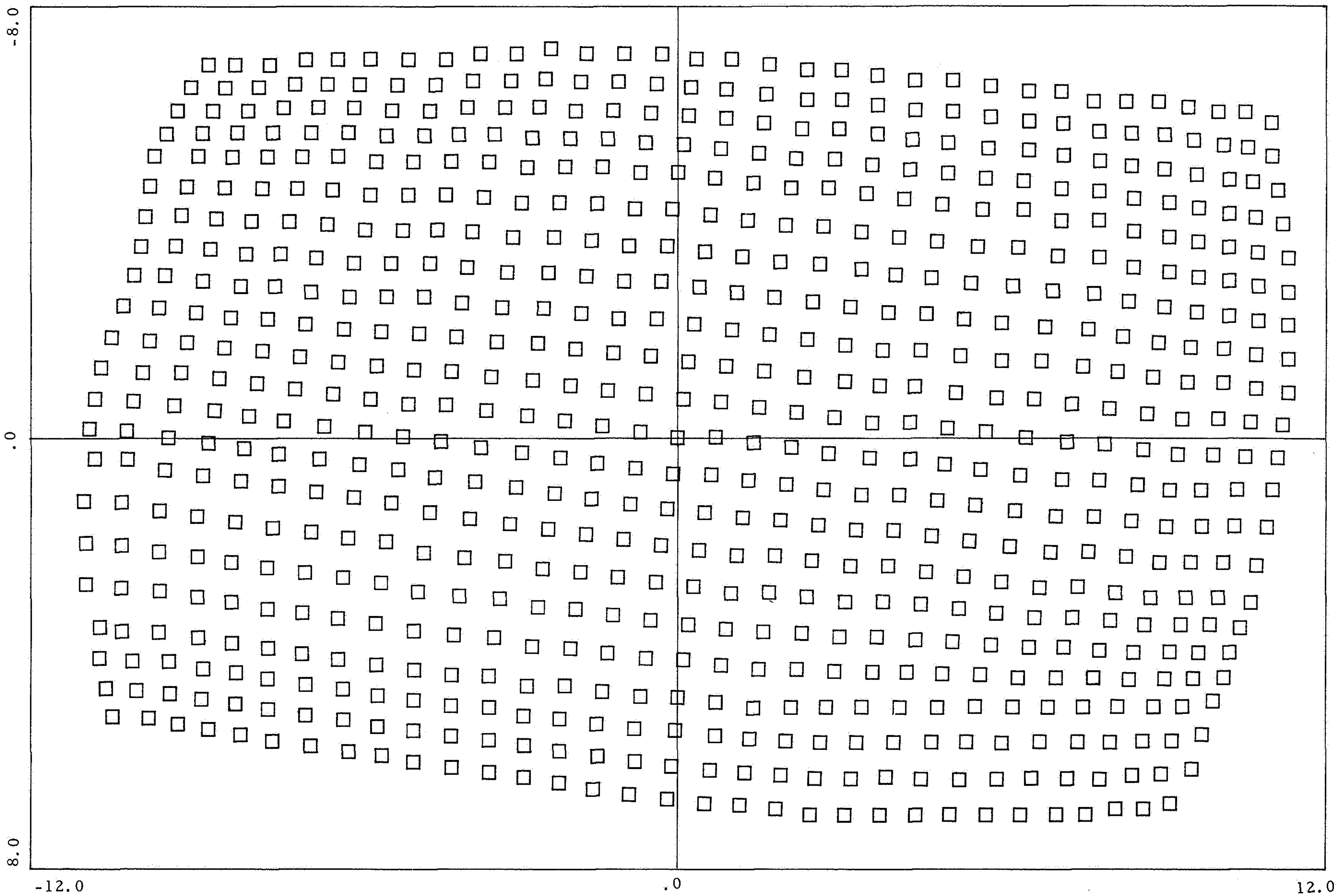


Figure 1-3. Display Raster Area (drawing from California Computer Products Plotter output).

DATA DISPLAY

Because the experiment can produce a large amount of data, it is necessary to depict this data in a form that facilitates fast and detailed evaluation. The ultimate display medium is a motion picture made from displays of the images on an SC 4020 microfilm plotter. It is also possible to obtain film for slide presentations from the SC 4020 as well as polaroid pictures from a special piece of equipment that displays individual pictures on a storage cathode ray tube. A sequence of pictures reproduced from 35mm. slide film is shown in Figure 1-4.

In addition to the filmed displays, the experiment data is printed in various formats that contain the intensity values by line for each element.

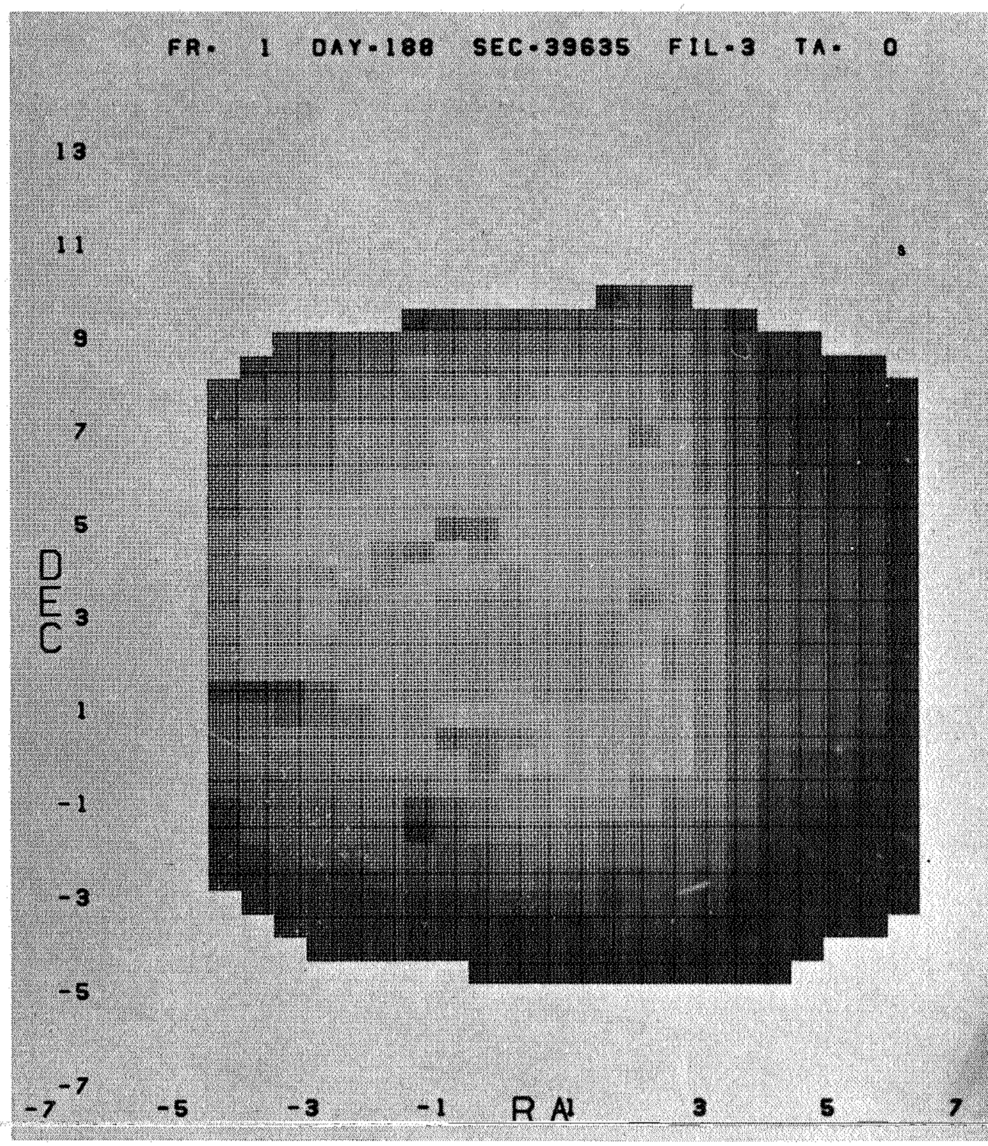


Figure 1-4. Display Example

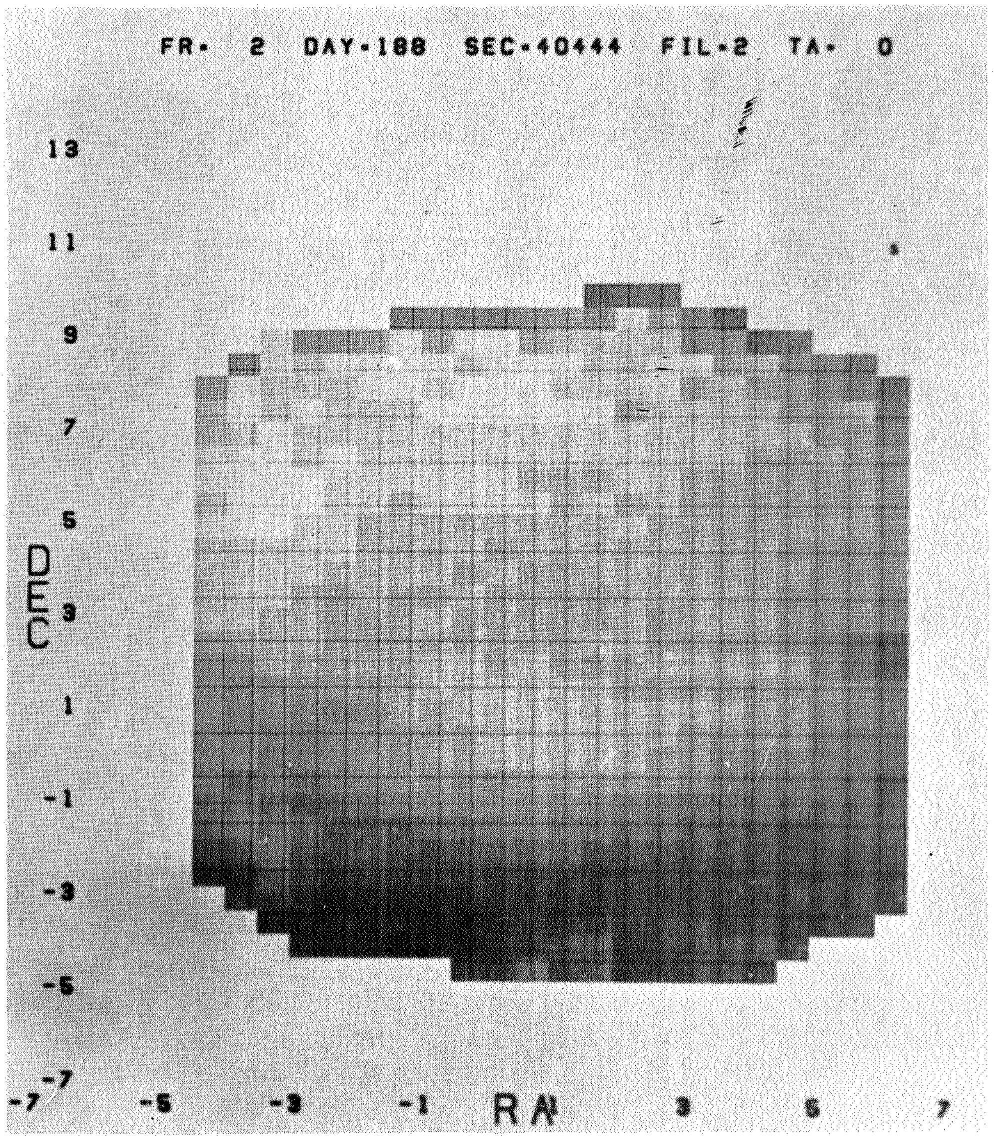


Figure 1-4. Display Example (continued)

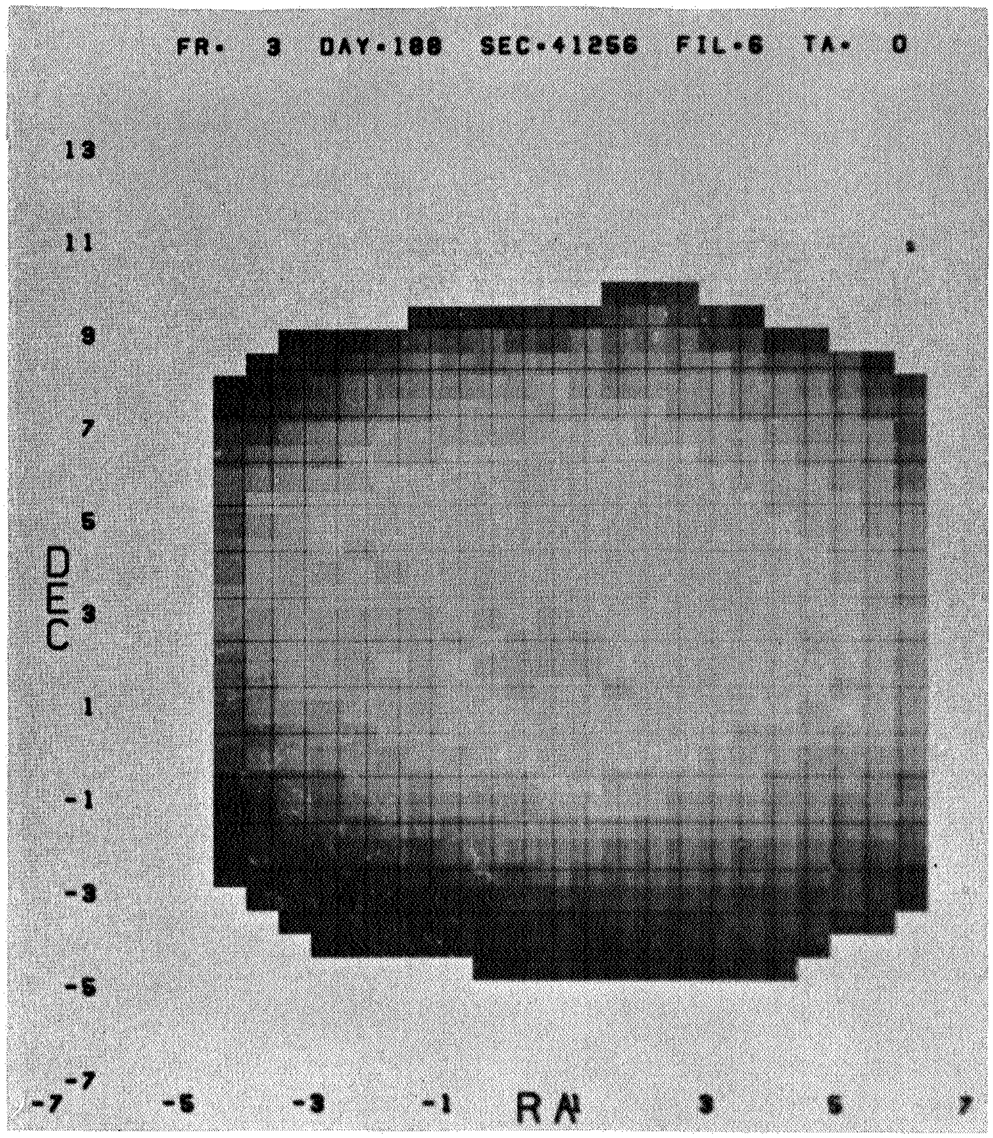


Figure 1-4. Display Example (continued)

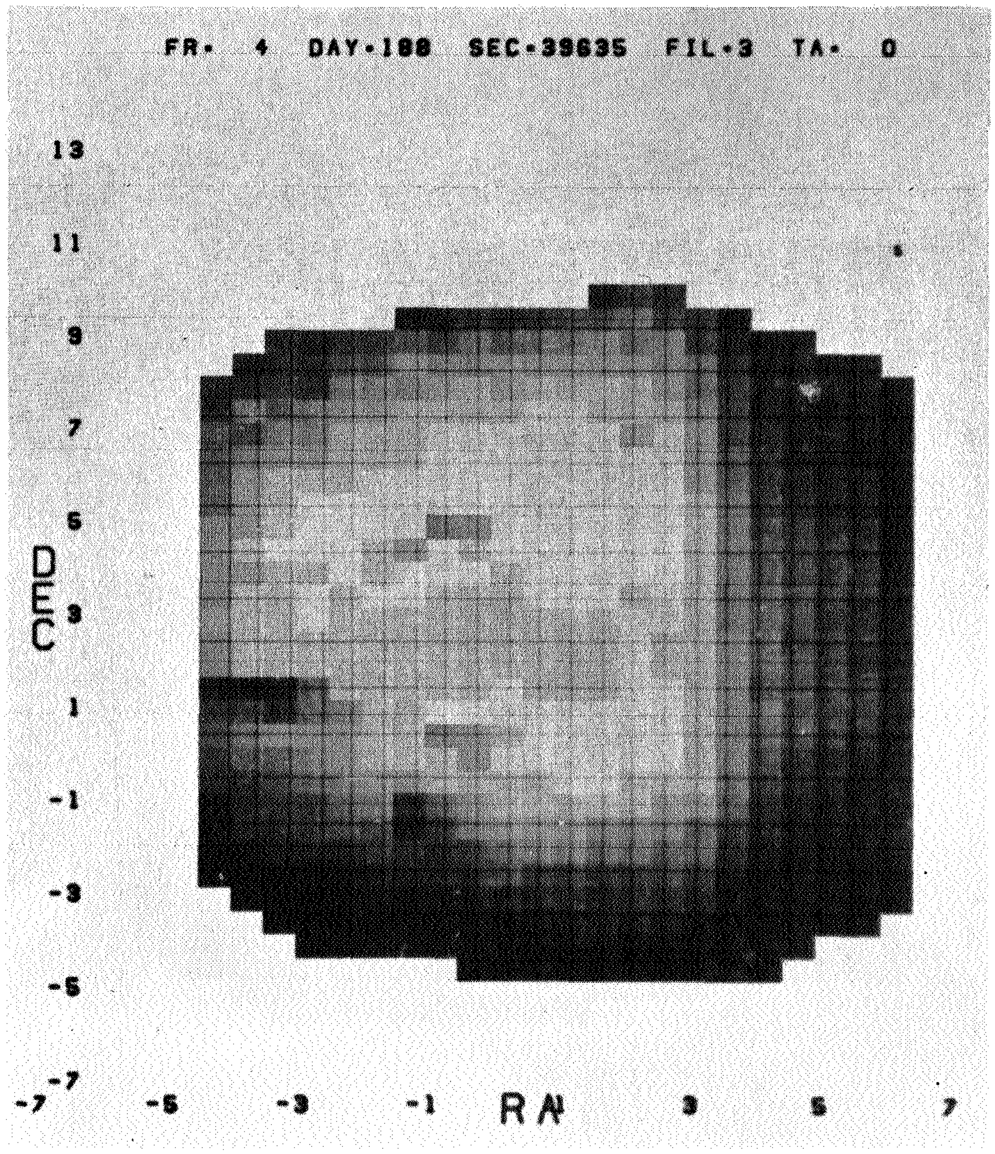


Figure 1-4. Display Example (continued)

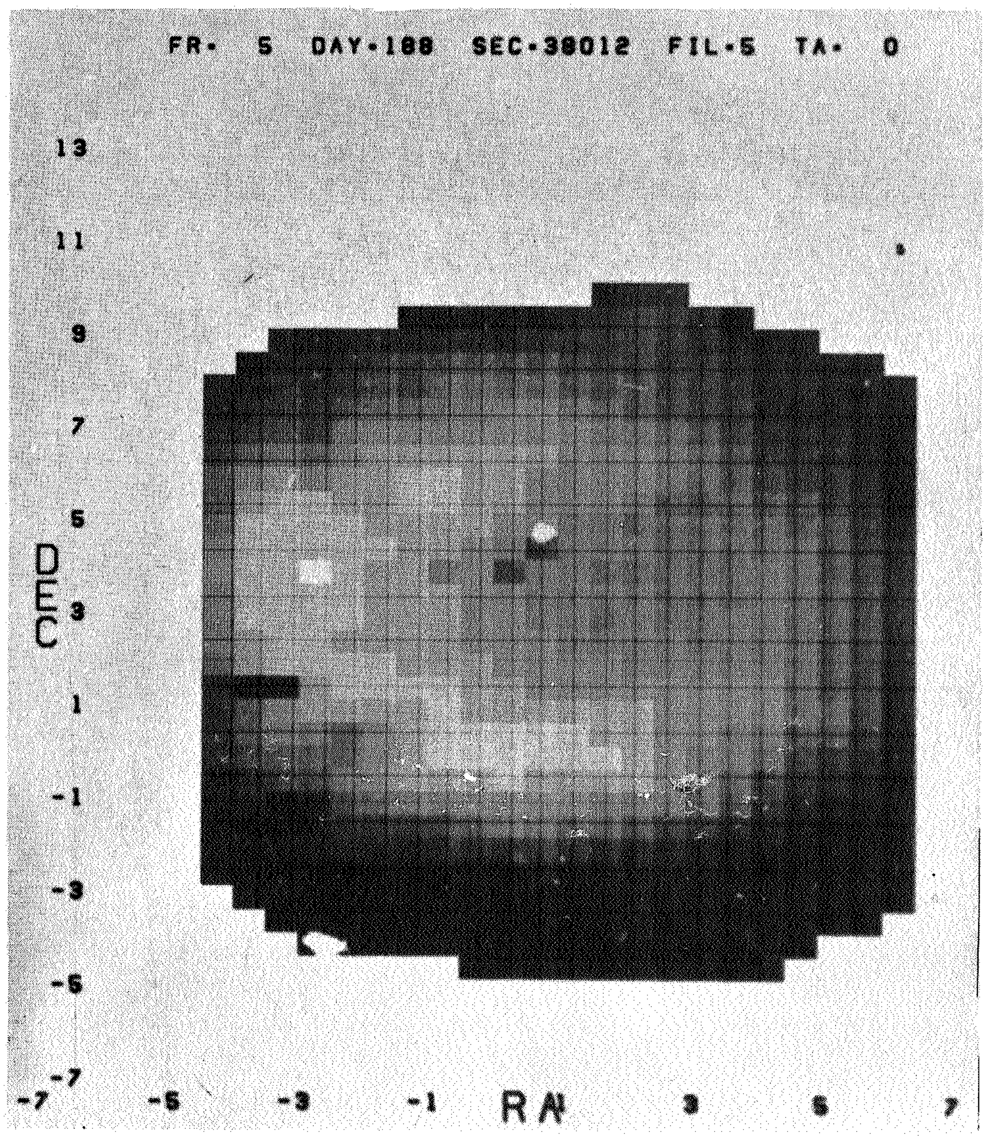


Figure 1-4. Display Example (continued)

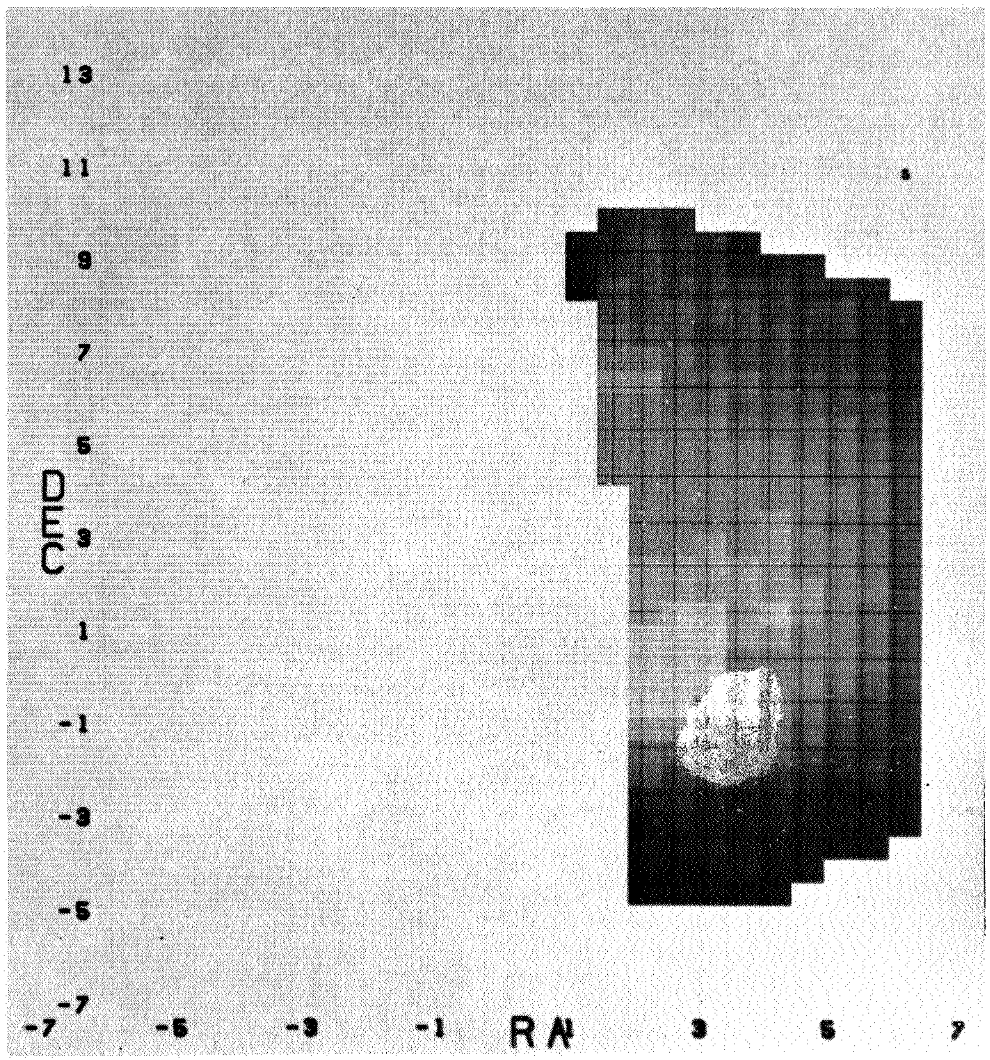


Figure 1-4. Display Example (continued)

DATA ANALYSIS SYSTEM

The Gegenschein Experiment Data Analysis System consists essentially of two Univac 1108 computer programs, a Processing Program and a Display Program. Figure 1-5 shows the relationships of these programs and their place in the entire OGO data processing system.

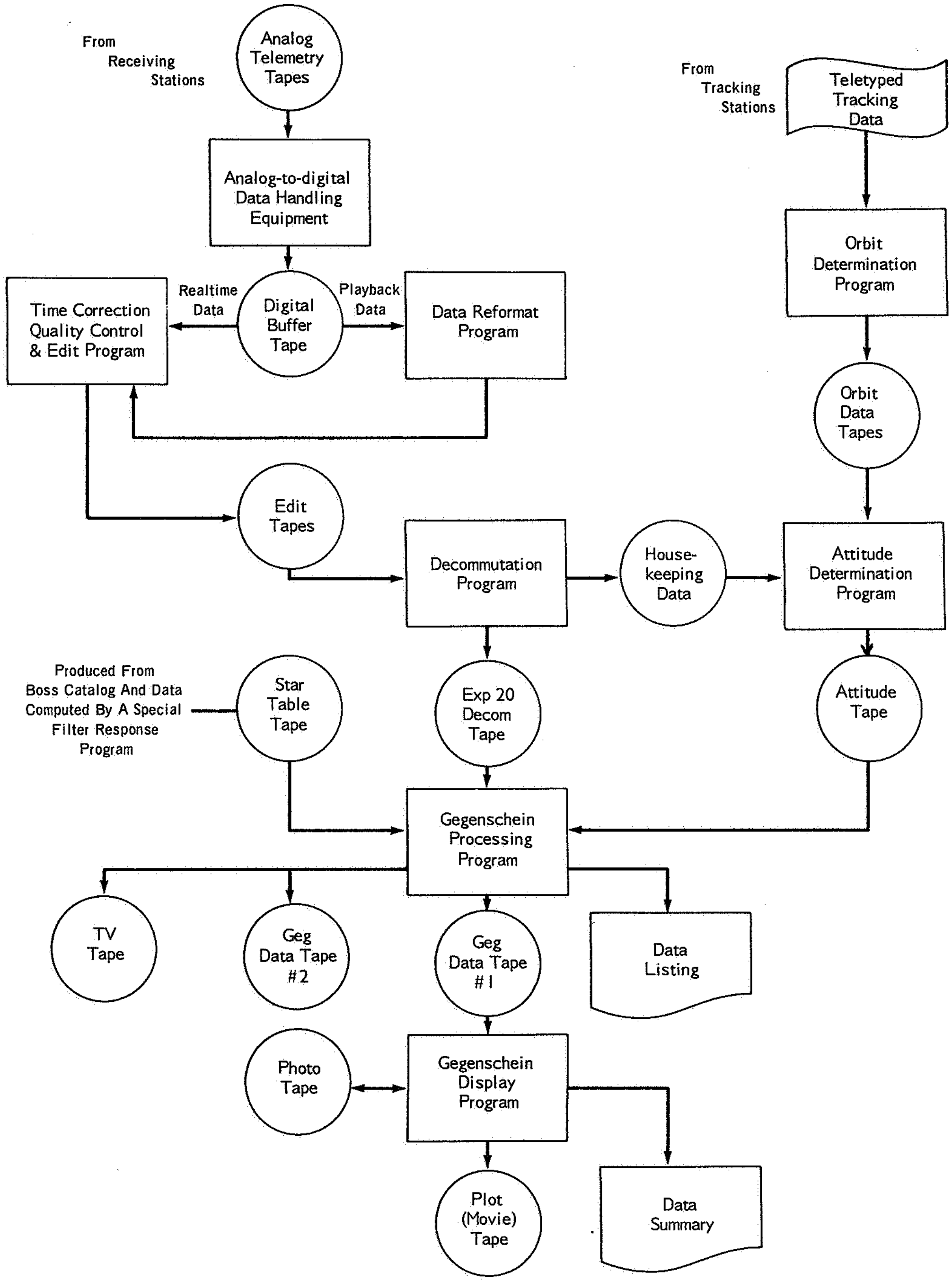


Figure 1-5. OGO Data Processing System Showing Gegenschein Experiment Programs

2. SYSTEM USAGE

GENERAL PROCEDURE

The Gegenschein Experiment Analysis System consists of two Univac 1108 programs as shown in Figure 2-1. They may be executed singly or as two consecutive jobs.

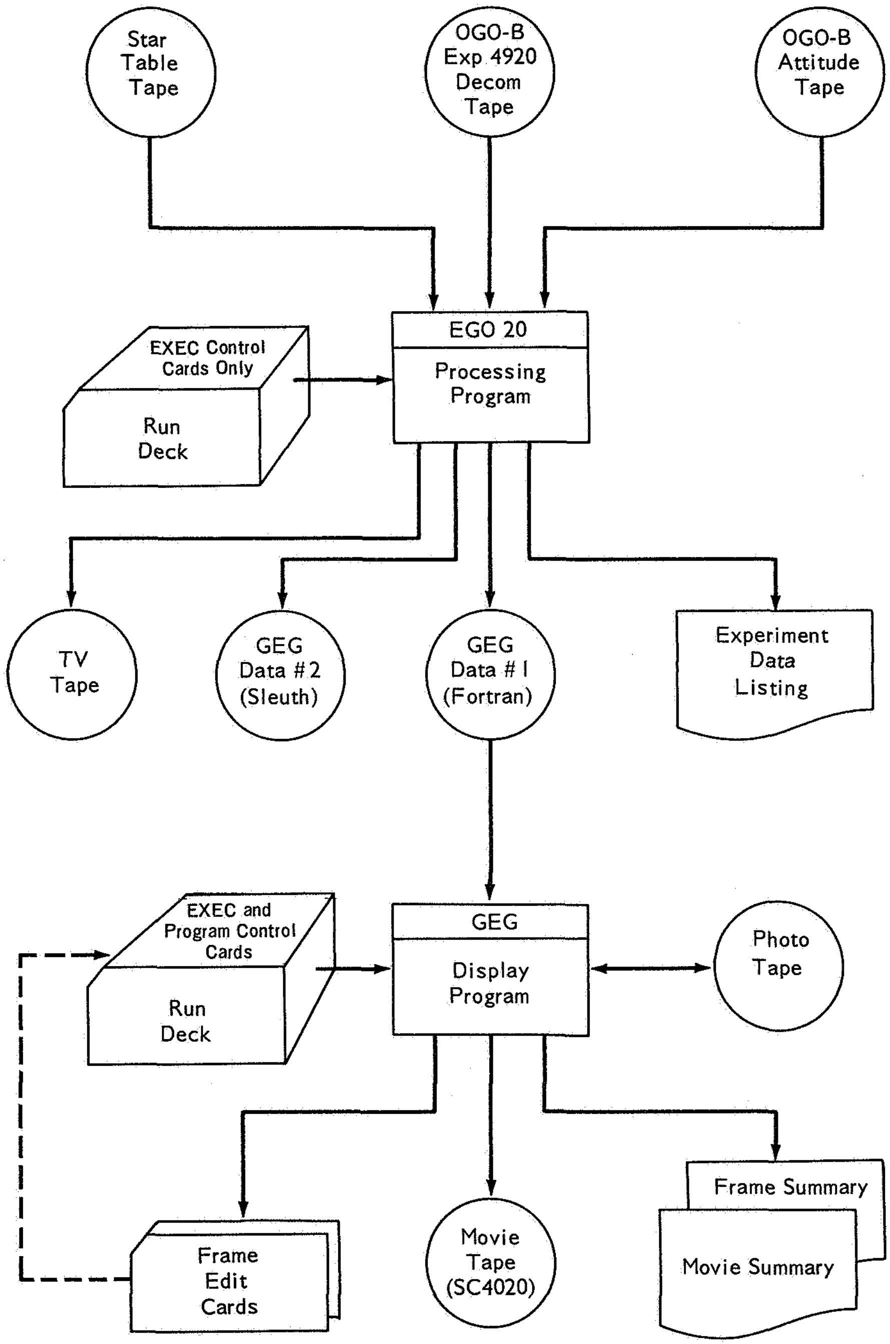


Figure 2-1. System Data Flow

PROCESSING PROGRAM

PROGRAM DESCRIPTION

The Processing Program correlates the decommutated experiment data and spacecraft attitude data, and re-creates the pictures taken by the camera. The results are output in the form of a printout of the picture values, a TV tape for oscilloscope display, and two gegenschein data tapes, one of which is input to the Display Program.

PROGRAM CONTROL

User control of the program is exercised entirely by console jump switches; no program control cards in the run deck are required (a Noise Parameter card may be included at user option; see option (6) in the discussion below).

USER OPTIONS

(1) Decom File Skipping (Switches 1 to 4, 6 to 10, and 14): the program will skip up to 10 files on the Decom Tape before processing data. The switch number indicates the number of files to skip except for switch 14, which causes five files to be skipped.

(2) Process One Decom File (Switch 15): processing may be restricted to one file on the Decom Tape by setting jump switch 15.

(3) RA and DEC Corrections (Switch 5): when switch 5 is set, the program will apply corrections to the right ascension and declination values computed from the Attitude Tape.

(4) Skip Attitude Tape (Switch 11): processing of spacecraft attitude data is bypassed when switch 11 is set.

(5) Bypass Starry Background Processing (Switch 12): the program normally filters out the starry background from the experiment frames. When switch 12 is set, this processing is bypassed and the background stars are not eliminated from the displays.

(6) Correct Raw Intensity Values (Switch 13): a user defined correction value may be subtracted from all raw intensity values by:

   (a) Defining the correction value in a Noise Parameter Card (cols. 1-6, right-adjusted) in the run deck, and

   (b) setting Switch 13.

RUN EXECUTION

Machine Requirements

Device	Yes	No	Amount/Number
Tape Drives	X		7
Card Reader	X		
Printer	X		
Punch		X	
Drum		X	
Disk		X	

Input-Output

	Description	Device
INPUT	Program Tape	Tape Z
	Table Tape	Tape I
	Decom Tape	Tape L
	Attitude Tape	Tape M
	Run Deck	Card Reader
OUTPUT	TV Tape	Tape P
	Gegenschein Data Tape #1 (Sleuth)	Tape Q
	Gegenschein Data Tape #2 (Fortran)	Tape N
	Data Listing	Printer

Tape Arrangement

	Description	Device	Op Label	Disposition
INPUT	Program	Z	EGO20	
	Exp. 20 Decom	L	DECOM	
	Exp. 20 Star Table	I	TABLE	
	OGO-B Attitude	M	ATTAPE	
OUTPUT	TV Tape	P	TVTAPE	For Oscilloscope Display
	Experiment Data #1	N	TAPE1	
	Experiment Data #2	Q	TAPE2	Input to Display Program as GEG tape.

Jump Switches

The following are jump switch options; no jump switches are required by the program.

Jump Switch	Position	Action
1-4 & 6-10	Set	Skip "n" files on the Decom Tape, where "n" is the switch number (see switches 14 and 15 below).
5	Set	Apply corrections to right ascension and declination values.
11	Set	Do not process Attitude Tape.
12	Set	Do not perform starry background processing.
13	Set	Read Noise Parameter Card (see run deck) and subtract parameter from raw intensity values.
14	Set	Skip 5 files on the Decom Tape.
15	Set	Process only one Decom File.

Run Deck Set-Up

∇ RUN (run name)

∇ MSG LOG NUMBER (number)

∇ ASG Z = EGO20

∇ ASG I = TABLE

∇ ASG L = DECOM

∇ ASG N = TAPE1

∇ ASG M = ATTAPE (not required if Jump Switch 11 is set)

∇ ASG Q = TAPE2

∇ ASG P = TVTAPE

∇ XQT CUR

TRW Z

ERS

IN Z

TRI Z

TOC (optional)

∇ XQT EGO20

Noise Parameter Card (optional - if present Jump Switch 13 must be set)

∇ FIN

Messages

Message	Text
A	UNRECOVERABLE ERROR ON ASPECT TAPE
B	WRONG ASPECT TAPE
C	A LINE EXCEEDED 32 ELEMENTS, SKIPPED PICTURE
D	PICTURE EXCEEDS 22 LINES, SKIPPED
E	BAD DECOM TAPE - CANNOT READ
F	TROUBLE WRITING TV TAPE
H	FOUND EOF
I	TROUBLE WRITING ON TAPE2

<table>
<tr><th>Message</th><th>Appears On</th><th colspan="3">Program Action</th><th>Operator Action</th></tr>
<tr><td>A</td><td>Typewriter</td><td colspan="3">Jumps to MERR$</td><td rowspan="9">None Required</td></tr>
<tr><td>B</td><td>Typewriter</td><td colspan="3">Jumps to MERR$</td></tr>
<tr><td>C</td><td>Printer</td><td colspan="3">Continues</td></tr>
<tr><td>D</td><td>Printer</td><td colspan="3">Continues</td></tr>
<tr><td>E</td><td>Typewriter</td><td colspan="3">Writes EOF on Q
Rewinds Q, N, P, L, M
Jumps to MEXIT$</td></tr>
<tr><td>F</td><td>Typewriter</td><td colspan="3">Jumps to MERR$</td></tr>
<tr><td rowspan="2">H</td><td rowspan="2">Printer</td><td rowspan="2">Jump Key 15</td><td>off</td><td>Does next Decom File</td></tr>
<tr><td>on</td><td>EOF on N, P, Q
Rewind N, P, Q, L, M
Jumps to MEXIT$</td></tr>
<tr><td>I</td><td>Typewriter</td><td colspan="3">Jumps to MERR$</td></tr>
</table>

DISPLAY PROGRAM

PROGRAM DESCRIPTION

This program generates a photo data tape from the gegenschein data tape produced by the Display Program, then produces an edited movie tape for use with the SC 4020 Microfilm Plotter (see Fig. 2-2). These functions are performed during the two major program processing phases, the preprocessing phase and the display phase.

In the preprocessing phase, one or more gegenschein tapes are introduced in time sequence to a filtering process where unrecognizable data frames are eliminated. All information contained in a valid frame is placed on the Photo Tape, which serves as a collection pool for the frame data. This tape will hold approximately 700 picture frame data sets; in later runs, additional sets may be added to the tape at user option.

Each data set constitutes a file on the tape; each frame is given a sequential number, which is also the file number. For each frame written on the Photo Tape, a Display Edit Card is punched with the frame number and a printout of the frame data is produced. At the option of the user, additional parameters may be punched into the cards to control frame editing during the display phase.

In the display phase, the data on the Photo Tape is converted to SC 4020 instructions for visual presentation under control of the Display Edit Cards produced in the preprocessing phase. The editing may compensate for wide ranging intensity levels or picture skewness (which can be determined by examination of the printout produced in the first phase).

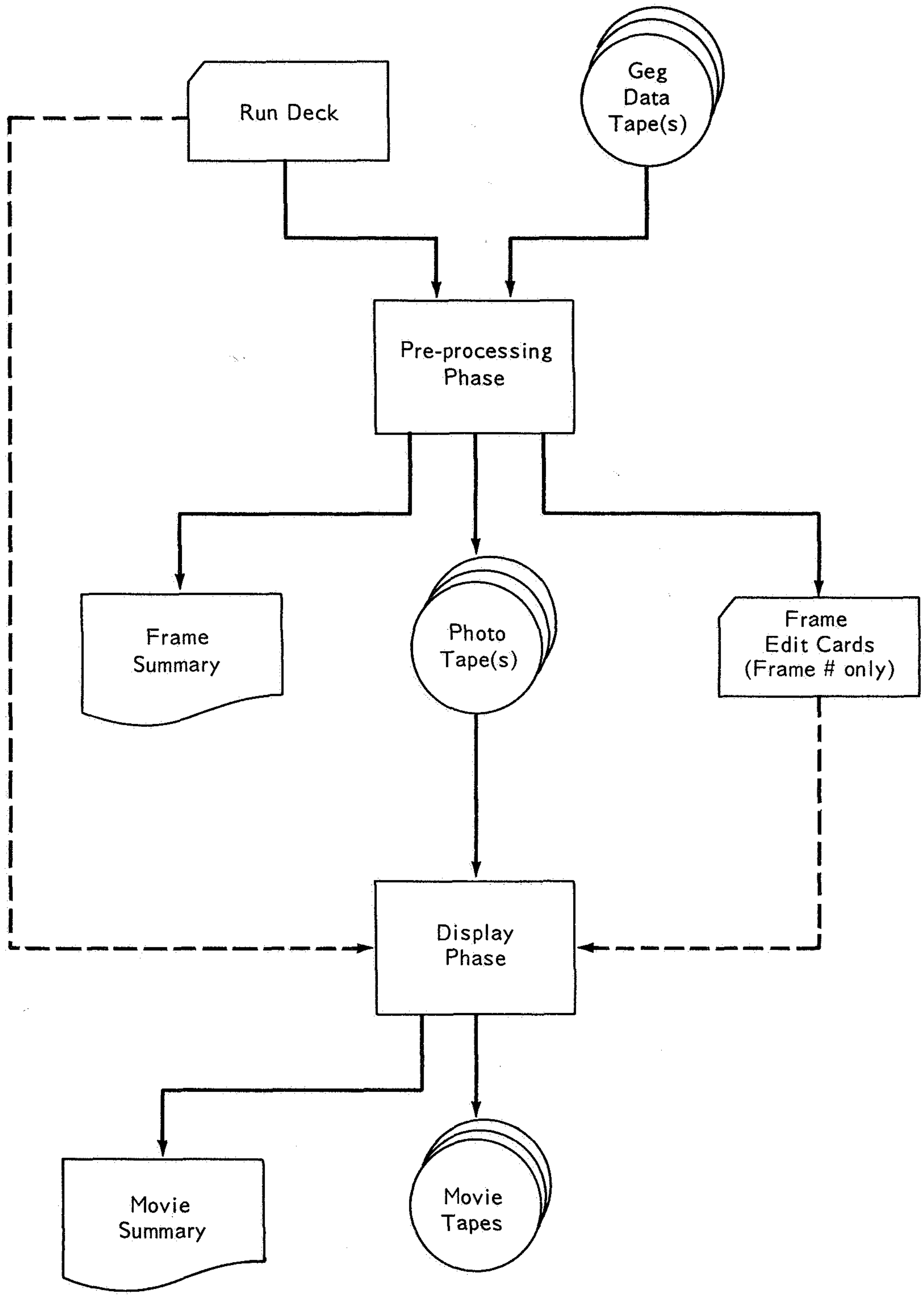


Figure 2-2. Display Program: Processing Phases and Data Flow

PROGRAM CONTROL

The program is controlled by the following control cards in the run deck (Figure 2-3):

(1) Basic Input Cards: this set of six cards gives the user control over the operation of the program and the format and amounts of data produced for display. The sixth card is the Master Overlay Card, which controls the format of all frames produced during the run; Display Edit Cards may be used to change the master overlay information for specified frames.

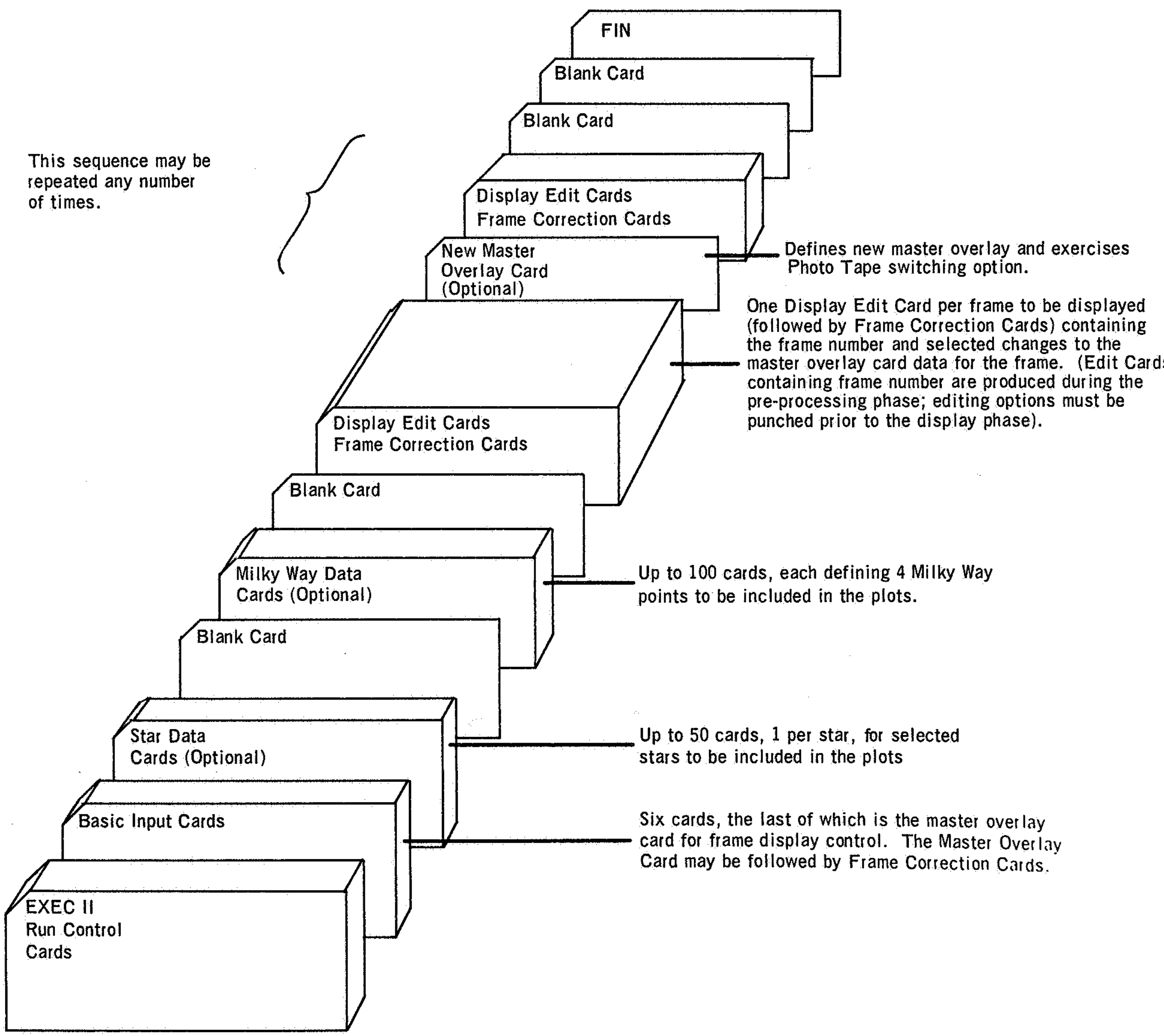


Figure 2-3. Display Program: Control Card Arrangement

(2) Star Data Cards: these cards may be included at user option to cause selected stars to be included in all picture frames produced during the run.

(3) Milky Way Data Cards: these cards may be included at user option to cause the milky way outline to be included in all frames produced during a run.

(4) Display Edit Cards: these cards, one for each frame, allow the user to control the order of frame display and to specify editing corrections to the master overlay defined in the basic input.

(5) Frame Correction Cards: these cards may be used to change the intensity levels of specified raster positions. When the change applies to all frames, the cards follow the Master Overlay Card; when the change applies to a particular frame, the cards follow the Display Edit Card for the frame.

USER OPTIONS

User options are exercised entirely by program control cards; no jump switch or other console options are provided.

(1) Gegenschein Tape(s) Option (Basic Input Card #4 - Word 4): the user has the option to bypass the preprocessing phase (by indicating no gegenschein tapes) or to process any number of tapes. When the phase is bypassed, the Photo Tape is assumed to contain valid frames from a prior run, which are formatted and written onto the Plot Tape under control of the Master Overlay Card (Basic Input Card #6) and the Display Edit Cards.

When gegenschein tapes are present, the contents of each are processed and written onto the Photo Tape before the display phase is entered. However, the program will stop (run termination) at the beginning of the display phase if either of the following conditions exist:

(a) A Photo Tape swap was made during preprocessing.

(b) No Display Edit Cards are present.

(2) Photo Tape File Skipping (Basic Input Card #4 - Word 5): when new frames are to be added to a valid Photo Tape (preprocessing phase), the user may define the number of tape files to be skipped before writing the new frames.

(3) Star Plots (Star Data Cards): a maximum of 50 selected stars may be included in all frames produced during the run by defining the star positions and intensities in Star Data Cards.

(4) Milky Way Plots (Milky Way Data Cards): a maximum of 400 points of the milky way may be included in all frames produced during the run by defining the point positions in the Milky Way Data Cards; the same intensity (a program constant) is used for all points defined.

(5) Frame Format Control (Basic Input Cards): the basic input cards give the user a number of options for controlling frame formats for all frames produced during the run (individual frame formats may be changed by frame editing options as described below). These options include the following:

(a) The number of right ascension (RA) columns and declination (DEC) rows per frame (Basic Input Card #4).

(b) The usable SC 4020 area, with position and size of titles and labels (Basic Input Cards #1, #4, and #5).

(c) Degree height and width of the data raster and the density factor (Basic Input Cards #4 and #5).

(d) The maximum number of frames to be output to the Photo Tape (Basic Input Card #1).

(e) High and low intensity parameters for the experiment camera filters (Basic Input Cards #2 and #3).

(6) Display Editing (Display Edit Cards): a number of options are available for controlling the format of individual frames. These are exercised by a combination of the Master Overlay Card (Basic Input Card #6) and the Display Edit Cards. The Master Overlay Card defines display values that can be changed from frame to frame by the user. The Display Edit Cards, one for each frame to be displayed, may be used to selectively preempt any master overlay value for the frame (the Display Edit Card format is essentially a duplicate of the Master Overlay Card format). The following rules pertain to use of the Display Edit Cards:

(a) A frame is displayed only if a Display Edit Card containing the frame number (at a minimum) is present in the run deck.

(b) Frames are displayed in Display Edit Card order.

For any frame, the following options may be exercised in the Display Edit Card:

(a) The size of the picture can be contracted or expanded in both height and width.

(b) Intensity level slopes can be changed for interpolation purposes (e.g., light pictures made darker, etc.)

(c) Projection of the first "n" and last "m" rasters may be deleted.

(d) Two raster position corrections may be induced. One is a fine correction where rasters are positioned $1/2^{\circ}$ apart; the other is a coarse correction which causes only wild values to be repositioned.

(e) Frame averaging may be selected for data received at the 8K bit rate (8 pictures per filter wheel position) and 64K bit rate (8 pictures per filter wheel position). The user has the option to average in all pictures for a frame and obtain one average plot, or to plot a frame and also cause it to be averaged in with others. On plotted frames, a frame number of zero indicates the results of an averaged set of frames.

(7) Intensity Correction Option (Frame Correction Cards): intensity corrections to individual rasters in all frames or a particular frame may be defined using a combination of data in the Master Overlay Card and Frame Correction Cards, or a combination of data in the Display Edit Cards and Frame Correction Cards.

The Frame Correction Cards contain the RA and DEC of the raster to be corrected. When the corrections apply to all frames generated during the run, the Frame Correction Cards follow the Master Overlay Card; the desired intensity levels are defined in words 6 and 7 of the Master Overlay Card.

When the corrections apply to a particular frame, the Frame Correction Cards follow the Display Edit Card for the frame; the desired intensity levels are defined in words 8 to 12 of the Display Edit Card.

In both cases, raw and/or corrected data may be corrected for intensity. When both types of corrections are present, the Frame Correction Cards for raw data must precede those for corrected data. The number of cards of each type must be specified in words 15 and 16 of the Master Overlay Card or the Display Edit Card as appropriate.

(8) Restart Option: the user has the option to introduce new Master Overlay Cards and associated Display Edit Cards in the same run; a new Master Overlay Card supercedes the preceding one. A further option is provided to indicate continuation with the current Photo Tape or to pause for mounting of a new tape.

CONTROL CARD FORMATS

Basic Input Cards

The basic input consists of the following six cards:

(1) Card #1: defines various parameters pertaining to the program and the run.

(2) Card #2: defines the high and low intensity values for filters 1 through 4 for both raw and corrected experiment data.

(3) Card #3: the same as Card 2 but for filters 5, 6, and 7.

(4) Card #4 and #5: define various parameters for program and plot control.

(5) Card #6: the Master Overlay Card for controlling display frame formats (changes in the master overlay may be specified for individual frames in Display Edit Cards).

Card #1 (Format: 16I5)

Word	Columns	Normal Value	Description
1	1-5	3	Gegenschein Data Tape assignment.
2	6-10	2	Photo Tape assignment.
3	11-15	1	Plot Tape assignment.
4	16-20	1	SC camera number.
5	21-25	10	Number of consecutive blank gegenschein data frames; signals end of data.
6	26-30	500	Maximum number of frames to be output to the Photo Tape.
7	31-35	412	Number of words in the Gegenschein Data Tape identification (ID) record.
8	36-40	704	Number of words per Gegenschein Data Tape data record.
9	41-45	9	Number of the ID record word containing the filter number.
10	46-50	50	Minimum allowable number of zero Right Ascension (RA) values (for filtering).
11	51-55	120	Minimum usable SC 4020 X border (upper left).
12	56-60	120	Minimum usable SC 4020 Y border (upper left).
13	61-65	960	Maximum usable SC 4020 X border (lower right).
14	66-70	960	Maximum usable SC 4020 Y border (lower right).
15	71-75	5	Number of Gegenschein Data Tape data records per ID record (data block).
16	76-80	16	Number of parameter words in this card (I5 format).

Card #2 (Format: 16I5)

Word	Columns	Description
1	1-5	Filter 1: low intensity for raw data.
2	6-10	Filter 1: high intensity for raw data.
3	11-15	Filter 1: low intensity for corrected data.
4	16-20	Filter 1: high intensity for corrected data.
5	21-25	Filter 2: low intensity for raw data.
6	26-30	Filter 2: high intensity for raw data.
7	31-35	Filter 2: low intensity for corrected data.
8	36-40	Filter 2: high intensity for corrected data.
9	41-45	Filter 3: low intensity for raw data.
10	46-50	Filter 3: high intensity for raw data.
11	51-55	Filter 3: low intensity for corrected data.
12	56-60	Filter 3: high intensity for corrected data.
13	61-65	Filter 4: low intensity for raw data.
14	66-70	Filter 4: high intensity for raw data.
15	71-75	Filter 4: low intensity for corrected data.
16	76-80	Filter 4: high intensity for corrected data.

Card #3 (Format: 12I5)

Word	Columns	Description
1	1-5	Filter 5: low intensity for raw data.
2	6-10	Filter 5: high intensity for raw data.
3	11-15	Filter 5: low intensity for corrected data.
4	16-20	Filter 5: high intensity for corrected data.
5	21-25	Filter 6: low intensity for raw data.
6	26-30	Filter 6: high intensity for raw data.
7	31-35	Filter 6: low intensity for corrected data.
8	36-40	Filter 6: high intensity for corrected data.
9	41-45	Filter 7: low intensity for raw data.
10	46-50	Filter 7: high intensity for raw data.
11	51-55	Filter 7: low intensity for corrected data.
12	56-60	Filter 7: high intensity for corrected data.

Card #4 (Format: 16I5)

Word	Columns	Normal Value	Description
1	1-5	608	Plot output buffer size (words).
2	6-10	22	Number of RA columns per frame.
3	11-15	32	Number of DEC rows per frame.
4	16-20	0 or n	Gegenschein Data Tape option: 0 = no Gegenschein Tape. n = number of Gegenschein Tapes to process.
5	21-25	n	Photo Tape file skip option: n = 0: photo tape is scratch. n ≠ 0: skip n files and add frames from the Gegenschein Tape.
6	26-30	3	Density factor: number of SC 4020 plot rasters per plot point.
7	31-35	5	Degrees error times 10 before course correction is made.
8	36-40	20	Number of plot output buffers.
9	41-45	2000	Number of words, times 10^{-3}, per Plot Tape before tape swap.
10	46-50	0 or 1	1 = print 704 RA, DEC, and intensity values per frame.
11	51-55	0 or 1	1 = print Gegenschein Data Tape label record data for each frame.
12	56-60	0 to 4	Overplotting options: 0 = no overplot. 1 = overplot with box. 2 = overplot with O (alphabetic). 3 = overplot with zero. 4 = plotting dot.

Card #4: (continued)

Word	Columns	Normal Value	Description
13	61-65	0 or 1	1 = print elapsed compute time for a picture.
14	66-70		Not used.
15	71-75		Number of repeat title frames (for movie).
16	76-80	40	SC 4020 Y raster for frame number and title.

Card #5 (Format: 13I5)

Word	Columns	Normal Value	Description
1	1-5	480	SC 4020 X raster for RA (horizontal title).
2	6-10	980	SC 4020 Y raster for RA (horizontal title).
3	11-15	60	SC 4020 X raster for DEC (vertical title).
4	16-20	500	SC 4020 Y raster for DEC (vertical title).
5	21-25	2	X magnification for words 1 and 3 above.
6	26-30	2	Y magnification for words 2 and 4 above.
7	31-35	50	X and Y displacement degrees, times 100, for horizontal and vertical grid markers.
8	36-40	100	X correction degrees, times 100, for horizontal grid markers.
9	41-45	1	X magnification for grid markers.
10	46-50	1	Y magnification for grid markers.
11	51-55	2	Number of degrees between markers.
12	56-60	50	Degree width of individual gegenschein raster, times 100.
13	61-65	50	Degree height of individual gegenschein raster, times 100.

Card #6 (Format: 16I5)

Word	Columns	Normal Value	Description
1	1-5	-1	Identifies the card as a master overlay and controls Photo Tape swapping as follows: -1 = "new" overlay - do not swap Photo Tape. -2 = "new" overlay - swap to the next Photo Tape.
2	6-10		Display data type indicator: 1 = display raw data 2 = display corrected data 0 = both raw and corrected data.
3	11-15		Number of repeat frames after the initial frame (for movie).
4	16-20		Width in degrees of RA display.
5	21-25		Height in degrees of DEC display.
6	26-30		SC 4020 low density level.
7	31-35		SC 4020 high density level.
8-11	36-55		Blank
12	56-60		Gegenschein start raster number.
13	61-65	704	Gegenschein stop raster number.
14	66-70		Raster correction (tune-up) flag: 0 = none 1 = fine −1 = coarse
15	71-75		Number of raw data Frame Correction Cards trailing this card.
16	76-80		Number of corrected data Frame Correction Cards trailing this card.

Star Data Cards

Word	Columns	Format	Description
1	1-5	I5	Star intensity: 0 to 32760 in the progression 0, 8, 16...32760.
2	6-15	F10.3	Star celestial right ascension.
3	16-25	F10.3	Star celestial declination.

Milky Way Data Cards (Format: 8F9.4)

Word	Columns	Description
1	1-9	Element 1: celestial RA.
2	10-18	Element 1: celestial DEC.
3	19-27	Element 2: celestial RA.
4	28-36	Element 2: celestial DEC.
5	37-45	Element 3: celestial RA.
6	46-54	Element 3: celestial DEC.
7	55-63	Element 4: celestial RA.
8	64-72	Element 4: celestial DEC.

Frame Edit Cards (Format: 16I5)

Word	Columns	Description
1	1-5	Display frame number.
2	6-10	Data flag: 1 = raw data 2 = corrected data 0 = both
3	11-15	Number of repeat frames after initial frame.
4	16-20	Degree width: RA.
5	21-25	Degree height: DEC.
6	26-30	SC 4020 low intensity level.
7	31-35	SC 4020 high intensity level.
8	36-40	Raw data low intensity level.
9	41-45	Raw data high intensity level.
10	46-50	Corrected data low intensity level.
11	51-55	Corrected data high intensity level.
12	56-60	Gegenschein start raster number.
13	61-65	Gegenschein stop raster number.
14	66-70	SC 4020 tune-up flag: 0 = none 1 = fine -1 = coarse
15	71-75	Either the number of raw data Frame Correction Cards trailing this card or a frame averaging flag: -1 = average in the frame. -2 = average in and plot the frame.
16	76-80	Either the number of corrected data Frame Correction Cards trailing this card or a frame averaging termination indicator in the format -xx, where xx = bit rate (1, 8, 64).

Frame Correction Card (2I5)

Word	Columns	Description
1	1-5	Right Ascension of the raster to be corrected.
2	6-10	Declination of the raster to be corrected.

RUN EXECUTION

Machine Requirements (Univac 1108)

Device	Yes	No	Amount/Number
Tape Drives	X		4
Card Reader	X		
Card Punch	X		
Printer	X		

Input-Output

	Description	Device
INPUT	Program Tape (TASK2)	Tape A
	Gegenschein Data Tape(s) (optional)	Tape D
	Photo Tape(s)	Tape C
	Run Deck	Card Reader
OUTPUT	Plot (Movie) Tape(s)	Tape C
	Photo Data Summary	Printer
	Movie Summary	Printer
	Edit Cards (if gegenschein tape used)	Punch

Tape Arrangement

	Description	Device	Op Label	Disposition
INPUT	Program Tape	A	TASK2	
	Gegenschein Data	D	GEG	
	Photo Tape	C	PHOTO	
OUTPUT	Plot Tape	B	PLOT	

Jump Switches

None

Run Deck Set-Up

∇ RUN (name)

∇ ASG A = TASK2

∇ ASG B = PLOT

∇ ASG C = PHOTO

∇ ASG D = GEG (optional)

∇ XQT CUR

TRW A

IN A

TRI A

∇ XQT GEGEN

Basic Input Cards (6 cards)

Star Data Cards (optional)

Blank Card

Milky Way Data Cards (optional)

Blank Card

Edit Cards (optional)

Blank Card

Blank Card

∇ FIN

Messages

Message	
A	FRAME NO. (XXX...8115...XXX)
B	TOSSED OUT GEG FRAME
C	SWAPPED GEG
D	GEG ALL DONE DID NOT SWAP PHOTO
E	ERROR PHOTO
F	NEW MASTER OVERLAY (XXX...1615...XXX)
G	SWAP 'PHOTO'

Message	Appears On	Program Action	Operator Action
A	Printer	Continues	None
B	Printer	Continues	None
C	Printer	Continues	None
D	Printer	Continues	None
E	Printer	Continues	None
F	Printer	Continues	None
G	Printer	Continues	Mount and ready new Photo Tape.

3.0 OUTPUT EXAMPLES

Figure 3-1 is an example of the printed output produced by the Processing Program; Figure 3-2 is an example of the Display Program output.

```
                                    DATA PROCESSING FOR EGO EXPERIMENT NO. 20
  FILE NUMBER      1
 FILTER WHEEL    4
 ID RECORD OF DECOMMUTATION TAPE
  SATELLITE IDENTIFICATION 64541
  YEAR 64
  STATION NUMBER  20
  ANALOG TAPE NUMBER 1102
  BUFFER TAPE NUMBER  971
  DATE OF DIGITIZATION 358
  BIT RATE(K.B.)      8
  EQUIPMENT GROUP 1
  BINARY TAPE NUMBER  899
  BINARY FILE NUMBER  1
                          DAY OF YEAR   SEC. OF DAY    MONTH      DAY       HRS       MIN        SEC
 BEGIN TIME OF PICTURE        337        57064          12         3        15        50          4
 END TIME OF PICTURE          337        57103          12         3        15        51         43
 TIME OF YAW MANEUVER          0           0             0         0         0         0          0
 START TIME OF ECLIPSE          0           0             0         0         0         0          0
 END TIME OF ECLIPSE           0           0             0         0         0         0          0
 ACCUMULATED SATELLITE TIME (SECONDS)    18514857
 TEMPERATURE OF SOEP BOX NO.1 (DEG. C) (-Y)        94       31.81
                                       (+Y)        74       41.00
 TEMPERATURE BODY PACKAGE (DEG. C)      127      19.86
 LOAD BUS VOLTAGE          211      29.71
 YAW ERROR (DEGREES)          197      14.21
 ARRAY ERROR (DEGREES)          205      12.44
 TRUE ANOMALY (DEGREES)    .0
 HEIGHT (KILOMETER)       .0
 SUN-EARTH-SATELLITE ANGLE (DEGREES)    .0
 BODY ATTITUDE      X(I)       X(J)       X(K)       Y(I)       Y(J)       Y(K)       Z(I)       Z(J)       Z(K)
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
 PADDLE ATTITUDE    X(I)       X(J)       X(K)       Y(I)       Y(J)       Y(K)       Z(I)       Z(J)       Z(K)
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
                   .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000    .000000
```

Figure 3-1. Processing Program - Output Example

.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000
.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000
.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000
.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000	.000000

ORBITAL POSITIONS			VELOCITY		
X	Y	Z	X	Y	Z
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000

RIGHT ASCENSION - DECLINATION - CORRECTED INTENSITY - RAW INTENSITY - FLAG

LINE NO. 0					LINE NO. 1					LINE NO. 2					LINE NO. 3				
4.950	7.000	.00	64	0	4.470	7.025	.00	32	0	3.920	7.050	.00	40	0	3.460	7.075	.00	32	0
4.950	6.550	.00	48	0	4.475	6.575	.00	32	0	3.935	6.660	.00	24	0	3.480	6.625	.00	40	0
4.950	6.100	.00	48	0	4.480	6.125	.00	40	0	3.950	6.150	.00	24	0	3.500	6.175	.00	32	0
4.950	5.650	.00	40	0	4.485	5.675	.00	24	0	3.965	5.700	.00	32	0	3.520	5.725	.00	32	0
4.950	5.150	.00	56	0	4.490	5.175	.00	24	0	3.980	5.200	.00	32	0	3.540	5.225	3636.36	40	0
4.950	4.700	1292.30	48	0	4.495	4.725	1777.79	32	0	3.995	4.750	1818.20	40	0	3.560	4.775	1481.48	40	0
4.950	4.250	2086.94	48	0	4.500	4.275	969.70	32	0	4.010	4.300	1090.90	48	0	3.580	4.325	888.77	48	0
4.950	3.800	1052.60	40	0	4.505	3.830	413.78	24	0	4.025	3.860	506.32	40	0	3.600	3.890	323.23	32	0
4.950	3.300	680.83	32	0	4.510	3.335	519.48	40	0	4.040	3.370	375.02	48	0	3.620	3.405	240.96	40	0
4.950	2.850	677.96	40	0	4.515	2.895	417.41	48	0	4.045	2.940	228.58	48	0	3.625	2.985	133.32	40	0
4.950	2.400	545.47	48	0	4.520	2.455	188.22	32	0	4.050	2.510	154.85	48	0	3.630	2.565	129.92	56	0
4.950	1.970	303.04	40	0	4.525	2.030	165.28	40	0	4.055	2.090	120.91	48	0	3.635	2.150	101.81	56	0
4.950	1.540	219.76	40	0	4.530	1.600	98.46	32	0	4.060	1.660	145.44	72	0	3.640	1.720	72.72	48	0
.000	.000	.00	0	0	4.535	1.140	98.28	40	0	4.070	1.200	147.93	88	0	3.655	1.260	63.41	48	0
.000	.000	.00	0	0	4.540	.675	99.60	48	0	4.080	.730	94.40	64	0	3.670	.785	68.60	56	0
.000	.000	.00	0	0	4.545	.225	89.57	48	0	4.090	.270	100.01	72	0	3.685	.315	66.25	56	0
.000	.000	.00	0	0	4.550	-.225	87.26	48	0	4.100	-.190	154.45	112	0	3.700	-.155	65.86	56	0
.000	.000	.00	0	0	4.530	-.682	103.15	56	0	4.075	-.655	145.70	104	0	3.675	-.628	65.86	56	0
.000	.000	.00	0	0	4.510	-1.140	76.64	40	0	4.050	-1.120	138.14	96	0	3.650	-1.100	67.09	56	0
.000	.000	.00	0	0	4.490	-1.560	97.58	48	0	4.025	-1.550	215.28	144	0	3.625	-1.540	69.16	56	0
.000	.000	.00	0	0	4.470	-2.015	70.34	32	0	4.000	-2.040	204.80	128	0	3.600	-2.035	73.70	56	0
.000	.000	.00	0	0	4.420	-2.545	201.52	80	0	3.950	-2.540	328.62	184	0	3.545	-2.535	92.74	64	0
.000	.000	.00	0	0	4.370	-3.045	193.92	64	0	3.900	-3.040	260.22	128	0	3.490	-3.035	92.57	56	0
.000	.000	.00	0	0	4.320	-3.545	217.06	56	0	3.850	-3.540	287.17	112	0	3.435	-3.535	98.98	48	0
.000	.000	.00	0	0	4.270	-4.030	302.68	56	0	3.800	-4.020	331.01	96	0	3.380	-4.010	151.37	56	0
.000	.000	.00	0	0	4.220	-4.550	384.00	48	0	3.745	-4.540	451.26	88	0	3.320	-4.530	236.26	56	0
.000	.000	.00	0	0	4.170	-4.970	600.00	48	0	3.690	-4.960	740.72	80	0	3.260	-4.950	291.96	40	0
.000	.000	.00	0	0	4.120	-5.405	975.60	40	0	3.635	-5.390	1403.52	80	0	3.200	-5.375	777.78	56	0
.000	.000	.00	0	0	4.070	-5.845	1538.44	40	0	3.580	-5.830	1599.98	56	0	3.140	-5.815	930.24	40	0
.000	.000	.00	0	0	4.022	-6.365	2222.24	40	0	3.528	-6.340	1739.12	40	0	3.082	-6.315	1481.48	40	0
.000	.000	.00	0	0	3.975	-6.870	2400.00	24	0	3.475	-6.840	2857.16	40	0	3.025	-6.810	2823.50	48	0
.000	.000	.00	0	0	3.928	-7.330	.00	32	0	3.422	-7.300	.00	40	0	2.968	-7.270	.00	56	0

LINE NO. 4 LINE NO. 5 LINE NO. 6 LINE NO. 7

Figure 3-1. Processing Program - Output Example (continued)

3.010	7.100	.00	40	0	2.580	7.200	.00	48	0	2.140	7.300	.00	32	0	1.750	7.400	.00	48	0
3.030	6.650	.00	40	0	2.595	6.750	.00	48	0	2.150	6.850	.00	32	0	1.755	6.950	.00	24	0
3.050	6.200	.00	48	0	2.610	6.300	.00	32	0	2.160	6.400	.00	32	0	1.760	6.500	.00	32	0
3.070	5.750	.00	40	0	2.625	5.850	.00	40	0	2.170	5.950	.00	40	0	1.765	6.050	.00	48	0
3.090	5.250	3692.30	48	0	2.640	5.345	2666.68	40	0	2.180	5.440	1500.00	24	0	1.770	5.535	1777.79	32	0
3.110	4.800	1250.00	40	0	2.655	4.890	1333.30	56	0	2.190	4.980	905.66	48	0	1.775	5.070	645.16	40	0
3.130	4.350	615.40	40	0	2.670	4.435	459.76	40	0	2.200	4.520	363.64	40	0	1.780	4.605	303.04	40	0
3.150	3.920	399.98	48	0	2.685	3.995	412.93	64	0	2.210	4.070	210.52	40	0	1.785	4.145	142.21	32	0
3.170	3.440	195.12	40	0	2.700	3.510	225.79	56	0	2.220	3.580	192.42	56	0	1.790	3.650	119.76	40	0
3.175	3.030	134.45	48	0	2.710	3.085	308.48	128	0	2.225	3.140	107.38	48	0	1.795	3.195	150.62	72	0
3.180	2.620	80.32	40	0	2.720	2.665	186.37	104	0	2.230	2.710	95.09	56	0	1.800	2.755	103.42	64	0
3.185	2.210	86.80	56	0	2.730	2.250	155.57	112	0	2.235	2.290	75.66	56	0	1.805	2.330	115.81	88	0
3.190	1.780	93.24	72	0	2.740	1.815	144.60	120	0	2.240	1.850	75.26	64	0	1.810	1.885	120.64	104	0
3.205	1.320	84.89	72	0	2.755	1.350	189.34	168	0	2.255	1.380	61.88	56	0	1.820	1.410	112.84	104	0
3.220	.840	99.00	88	0	2.770	.865	258.00	240	0	2.270	.890	59.14	56	0	1.830	.915	116.26	112	0
3.235	.360	76.41	72	0	2.785	.380	267.52	256	0	2.285	.400	65.41	64	0	1.840	.420	152.15	152	0
3.250	-.120	94.60	88	0	2.800	-.105	313.73	304	0	2.300	-.090	80.40	80	0	1.850	-.075	160.00	160	0
3.225	-.600	102.82	96	0	2.770	-.590	198.53	192	0	2.270	-.580	63.04	64	0	1.825	-.570	158.26	168	0
3.200	-1.080	77.69	72	0	2.740	-1.075	158.38	152	0	2.240	-1.070	80.60	80	0	1.800	-1.065	188.16	192	0
3.175	-1.530	97.24	88	0	2.710	-1.525	178.58	168	0	2.210	-1.520	100.70	96	0	1.775	-1.515	223.78	216	0
3.150	-2.030	102.34	88	0	2.680	-2.025	185.64	168	0	2.180	-2.020	86.96	80	0	1.750	-2.015	189.20	176	0
3.100	-2.530	92.88	72	0	2.645	-2.525	174.53	144	0	2.160	-2.520	105.25	88	0	1.735	-2.515	179.66	152	0
3.050	-3.030	118.48	80	0	2.610	-3.025	155.57	112	0	2.140	-3.020	130.27	96	0	1.720	-3.015	212.48	160	0
3.000	-3.530	172.99	96	0	2.575	-3.525	171.91	104	0	2.120	-3.520	144.06	88	0	1.705	-3.515	285.12	176	0
2.950	-4.000	170.21	72	0	2.540	-3.995	234.30	112	0	2.100	-3.990	154.72	80	0	1.690	-3.985	278.92	152	0
2.890	-4.520	257.11	72	0	2.485	-4.510	255.82	88	0	2.050	-4.500	234.08	88	0	1.655	-4.490	352.94	144	0
2.830	-4.940	387.90	64	0	2.430	-4.930	369.22	72	0	2.000	-4.920	310.32	72	0	1.620	-4.910	507.42	136	0
2.770	-5.360	636.36	56	0	2.375	-5.350	466.03	48	0	1.950	-5.340	380.93	48	0	1.585	-5.330	644.26	96	0
2.710	-5.800	923.09	48	0	2.320	-5.785	933.35	56	0	1.900	-5.770	823.54	56	0	1.550	-5.755	1263.17	96	0
2.655	-6.290	1250.00	40	0	2.270	-6.270	1333.34	48	0	1.855	-6.250	1025.64	40	0	1.518	-6.230	1860.48	80	0
2.600	-6.780	2000.00	40	0	2.220	-6.755	1454.56	32	0	1.810	-6.730	1739.12	40	0	1.485	-6.705	1600.00	40	0
2.545	-7.240	.00	40	0	2.170	-7.205	.00	48	0	1.765	-7.170	4800.00	48	0	1.452	-7.125	2909.09	32	0

LINE NO. 8					LINE NO. 9					LINE NO.10					LINE NO.11				
1.380	7.500	.00	48	0	1.010	7.500	.00	48	0	.550	7.500	.00	40	0	.140	7.500	.00	56	0
1.380	7.050	.00	40	0	1.005	7.050	.00	48	0	.545	7.050	.00	48	0	.135	7.050	.00	56	0
1.380	6.600	.00	40	0	1.000	6.600	.00	56	0	.540	6.600	.00	40	0	.130	6.600	.00	64	0
1.380	6.150	.00	40	0	.995	6.150	.00	40	0	.535	6.150	.00	24	0	.125	6.150	.00	48	0
1.380	5.630	2000.00	40	0	.990	5.637	1600.00	32	0	.530	6.643	2000.00	40	0	.120	5.650	2400.00	48	0
1.380	5.160	438.37	32	0	.985	5.173	666.67	48	0	.525	5.187	563.40	40	0	.115	5.200	685.73	48	0
1.380	4.690	256.08	40	0	.980	4.710	266.68	40	0	.520	4.730	386.23	56	0	.105	4.750	228.58	32	0
1.380	4.220	184.61	48	0	.975	4.247	190.46	48	0	.515	4.273	296.28	72	0	.100	4.300	170.20	40	0
1.380	3.720	191.02	72	0	.970	3.707	173.89	64	0	.510	3.723	156.02	56	0	.095	3.800	137.14	48	0
1.380	3.250	141.19	72	0	.968	3.283	95.62	48	0	.505	3.317	178.46	88	0	.090	3.350	98.98	48	0
1.380	2.800	110.74	72	0	.965	2.833	99.71	64	0	.500	2.867	164.32	104	0	.085	2.900	89.60	56	0
1.380	2.370	164.10	128	0	.962	2.397	93.17	72	0	.495	2.423	187.78	144	0	.080	2.450	63.17	48	0
1.380	1.920	147.07	128	0	.960	1.947	91.92	80	0	.490	1.973	230.00	200	0	.060	2.000	101.20	88	0
1.385	1.440	119.17	112	0	.958	1.460	102.05	96	0	.480	1.480	246.62	232	0	.040	1.500	76.61	72	0
1.390	.940	106.08	104	0	.955	.960	114.02	112	0	.470	.980	276.08	272	0	.020	1.000	73.08	72	0
1.395	.440	117.60	120	0	.952	.460	118.44	120	0	.460	.480	373.37	376	0	.000	.500	96.00	96	0
1.400	-.060	101.81	112	0	.950	-.040	130.90	144	0	.450	-.020	589.03	648	0	.000	.000	80.00	80	0
1.380	-.560	100.91	112	0	.935	-.540	149.28	160	0	.445	-.520	410.43	424	0	.000	-.500	112.56	112	0
1.360	-1.060	114.24	120	0	.920	-1.040	171.25	176	0	.440	-1.020	357.48	360	0	.000	-1.000	121.80	120	0
1.340	-1.510	114.46	112	0	.905	-1.490	197.95	192	0	.435	-1.470	398.59	384	0	.000	-1.450	108.89	104	0
1.320	-2.010	120.40	112	0	.890	-1.990	189.20	176	0	.430	-1.970	408.71	376	0	.000	-1.950	133.32	120	0
1.315	-2.510	130.70	112	0	.885	-2.490	198.58	168	0	.425	-2.470	546.29	456	0	.000	-2.450	145.44	120	0
1.310	-3.010	135.10	104	0	.880	-2.990	199.27	152	0	.420	-2.970	644.65	488	0	.000	-2.950	149.30	112	0
1.305	-3.510	154.08	96	0	.875	-3.490	200.58	128	0	.415	-3.470	758.38	496	0	.000	-3.450	167.22	112	0

Figure 3-1. Processing Program - Output Example (continued)

1.300	-3.980	128.59	72	0
1.275	-4.480	181.84	80	0
1.250	-4.900	236.09	72	0
1.225	-5.320	372.10	64	0
1.200	-5.740	658.84	56	0
1.175	-6.210	1217.38	56	0
1.150	-6.680	2074.07	56	0
1.125	-7.100	4666.65	56	0

.870	-3.953	239.50	136	0
.860	-4.453	245.06	112	0
.850	-4.867	272.45	88	0
.840	-5.280	516.10	96	0
.830	-5.693	818.21	72	0
.820	-6.157	1098.05	56	0
.810	-6.620	1714.27	48	0
.800	-7.033	3692.30	48	0

.410	-3.927	512.97	296	0
.405	-4.427	338.24	160	0
.400	-4.833	374.27	128	0
.395	-5.240	437.80	88	0
.390	-5.647	1043.52	96	0
.385	-6.103	1333.37	72	0
.380	-6.560	1655.18	48	0
.375	-6.967	4000.02	56	0

.000	-3.900	164.06	96	0
.000	-4.400	195.94	96	0
.000	-4.800	222.24	80	0
.000	-5.200	334.87	72	0
.000	-5.600	673.66	64	0
.000	-6.050	933.35	56	0
.000	-6.500	1866.65	56	0
.000	-6.900	2133.34	32	0

LINE NO.12

-.300	7.508	.00	40	0
-.310	7.058	.00	32	0
-.320	6.608	.00	32	0
-.330	6.158	.00	32	0
-.340	5.658	2105.28	40	0
-.350	5.208	738.48	48	0
-.360	4.758	430.75	56	0
-.370	4.304	260.40	56	0
-.380	3.804	188.22	64	0
-.385	3.354	185.24	88	0
-.390	2.904	130.08	80	0
-.395	2.454	172.93	128	0
-.400	2.004	152.06	128	0
-.425	1.508	131.88	120	0
-.450	1.012	142.80	136	0
-.475	.516	149.18	144	0
-.500	.020	181.46	176	0
-.495	-.468	240.35	232	0
-.490	-.964	261.14	248	0
-.485	-1.410	234.79	216	0
-.480	-1.910	274.32	240	0
-.480	-2.414	270.00	216	0
-.480	-2.914	274.00	200	0
-.480	-3.418	332.21	216	0
-.480	-3.868	313.10	176	0
-.470	-4.368	295.65	136	0
-.460	-4.764	423.50	144	0
-.450	-5.160	560.00	112	0
-.440	-5.560	1011.47	88	0
-.430	-6.010	1185.15	64	0
-.420	-6.460	1999.98	56	0
-.410	-6.860	4571.46	64	0

LINE NO.13

-.730	7.516	.00	32	0
-.740	7.066	.00	40	0
-.750	6.616	.00	56	0
-.760	6.166	.00	48	0
-.770	5.666	4235.33	72	0
-.780	5.216	827.57	48	0
-.790	4.766	547.01	64	0
-.800	4.308	451.26	88	0
-.810	3.808	300.00	96	0
-.820	3.358	503.33	224	0
-.830	2.908	519.18	296	0
-.840	2.458	414.43	288	0
-.850	2.008	383.95	304	0
-.875	1.516	291.65	248	0
-.900	1.024	279.25	248	0
-.925	.532	371.28	336	0
-.950	.040	288.55	264	0
-.940	-.436	236.09	216	0
-.930	-.928	362.44	328	0
-.920	-1.370	327.17	288	0
-.910	-1.870	314.16	264	0
-.905	-2.378	206.40	160	0
-.900	-2.878	192.85	136	0
-.895	-3.386	232.27	144	0
-.890	-3.836	226.44	120	0
-.880	-4.336	244.71	104	0
-.870	-4.728	283.89	88	0
-.860	-5.120	319.98	56	0
-.850	-5.520	708.85	56	0
-.840	-5.970	999.98	48	0
-.830	-6.420	1538.48	40	0
-.820	-6.820	1076.92	40	0

LINE NO.14

-1.210	7.524	.00	48	0
-1.220	7.074	.00	48	0
-1.230	6.624	.00	56	0
-1.240	6.174	.00	48	0
-1.250	5.674	2133.34	32	0
-1.260	5.224	800.00	40	0
-1.270	4.774	304.77	32	0
-1.280	4.312	182.85	32	0
-1.290	3.812	142.84	40	0
-1.310	3.362	123.07	48	0
-1.330	2.912	96.00	48	0
-1.350	2.462	89.60	56	0
-1.370	2.012	89.15	64	0
-1.390	1.524	112.82	88	0
-1.410	1.036	97.92	80	0
-1.430	.548	113.57	96	0
-1.450	.060	103.49	88	0
-1.435	-.404	141.12	120	0
-1.420	-.892	132.50	112	0
-1.405	-1.330	126.05	104	0
-1.390	-1.830	152.88	120	0
-1.385	-2.342	143.42	104	0
-1.380	-2.842	196.86	128	0
-1.375	-3.354	252.58	144	0
-1.370	-3.804	233.30	112	0
-1.355	-4.304	281.11	104	0
-1.340	-4.692	338.45	88	0
-1.325	-5.080	480.02	72	0
-1.310	-5.480	1028.59	72	0
-1.295	-5.930	1523.78	64	0
-1.280	-6.380	1391.30	32	0
-1.265	-6.780	3636.36	40	0

LINE NO.15

-1.690	7.532	.00	40	0
-1.700	7.082	.00	40	0
-1.710	6.632	.00	32	0
-1.720	6.182	.00	32	0
-1.730	5.682	3200.00	32	0
-1.740	5.232	1142.84	40	0
-1.750	4.782	519.48	40	0
-1.760	4.316	342.86	48	0
-1.770	3.816	260.46	56	0
-1.795	3.366	244.08	72	0
-1.820	2.916	379.01	144	0
-1.845	2.466	391.55	184	0
-1.870	2.016	361.71	208	0
-1.890	1.532	342.05	224	0
-1.910	1.048	412.70	288	0
-1.930	.564	328.80	240	0
-1.950	.080	356.66	264	0
-1.930	-.372	421.51	312	0
-1.910	-.856	533.51	392	0
-1.890	-1.290	540.57	392	0
-1.870	-1.790	578.54	408	0
-1.860	-2.306	598.58	392	0
-1.850	-2.806	772.92	456	0
-1.840	-3.322	1380.54	704	0
-1.830	-3.772	936.58	384	0
-1.810	-4.272	933.24	280	0
-1.790	-4.656	1066.69	224	0
-1.770	-5.040	1530.50	176	0
-1.750	-5.440	2933.39	176	0
-1.730	-5.890	4114.22	144	0
-1.710	-6.340	5200.00	104	0
-1.690	-6.740	7200.00	72	0

LINE NO.16

-2.220	7.540	.00	48	0
-2.235	7.090	.00	32	0
-2.250	6.640	.00	40	0
-2.265	6.190	.00	40	0
-2.280	5.690	.00	40	0
-2.295	5.240	1600.00	40	0
-2.310	4.790	1018.19	56	0
-2.325	4.320	480.00	48	0
-2.340	3.820	320.02	48	0
-2.365	3.370	319.97	72	0
-2.390	2.920	266.64	80	0
-2.415	2.470	169.28	64	0
-2.440	2.020	179.76	80	0
-2.455	1.540	160.00	80	0

LINE NO.17

-2.700	7.575	.00	32	0
-2.720	7.125	.00	24	0
-2.740	6.670	.00	24	0
-2.760	6.220	.00	24	0
-2.780	5.720	.00	32	0
-2.800	5.270	3200.00	32	0
-2.820	4.815	1333.34	32	0
-2.840	4.350	480.00	24	0
-2.860	3.850	282.36	24	0
-2.890	3.400	296.28	40	0
-2.920	2.950	280.00	56	0
-2.950	2.500	392.50	104	0
-2.980	2.050	363.60	120	0
-2.985	1.575	396.87	152	0

LINE NO.18

-3.230	7.610	.00	40	0
-3.255	7.160	.00	40	0
-3.280	6.700	.00	32	0
-3.305	6.250	.00	32	0
-3.330	5.750	.00	24	0
-3.355	5.300	.00	40	0
-3.380	4.840	4666.65	56	0
-3.405	4.380	1920.00	48	0
-3.430	3.880	1531.94	72	0
-3.460	3.430	1156.61	96	0
-3.490	2.980	1533.27	184	0
-3.520	2.530	2200.00	352	0
-3.550	2.080	1038.53	216	0
-3.550	1.610	1225.73	304	0

LINE NO.19

-3.750	7.645	.00	16	0
-3.780	7.195	.00	24	0
-3.810	6.730	.00	40	0
-3.840	6.280	.00	24	0
-3.870	5.780	.00	32	0
-3.900	5.330	.00	40	0
-3.930	4.865	.00	32	0
-3.960	4.410	3076.92	40	0
-3.990	3.910	1600.00	40	0
-4.010	3.460	545.45	24	0
-4.030	3.010	625.00	40	0
-4.050	2.560	470.60	40	0
-4.070	2.110	266.66	32	0
-4.065	1.645	266.68	40	0

Figure 3-1. Processing Program - Output Example (continued)

-2.470	1.060	144.16	80	0	-2.990	1.100	387.91	168	0	-3.550	1.140	1249.92	360	0	-4.060	1.180	228.56	40	0
-2.485	.580	133.36	80	0	-2.995	.630	353.64	168	0	-3.550	.680	1501.58	488	0	-4.055	.730	205.12	40	0
-2.500	.100	128.00	80	0	-3.000	.180	304.00	152	0	-3.550	.220	2125.61	744	0	-4.500	.280	297.66	64	0
-2.480	-.340	126.96	80	0	-2.985	-.285	329.45	168	0	-3.540	-.230	2200.18	792	0	-4.045	-.175	278.27	64	0
-2.460	-.820	114.26	72	0	-2.970	-.755	329.45	168	0	-3.530	-.690	2257.76	824	0	-4.040	-.625	272.32	64	0
-2.440	-1.250	141.94	88	0	-2.955	-1.180	352.00	176	0	-3.520	-1.110	1509.91	536	0	-4.035	-1.040	243.49	56	0
-2.420	-1.750	119.02	72	0	-2.940	-1.670	333.28	160	0	-3.510	-1.590	894.06	304	0	-4.030	-1.510	409.29	88	0
-2.405	-2.270	154.35	88	0	-2.915	-2.180	327.31	144	0	-3.470	-2.090	929.09	288	0	-3.980	-2.000	336.83	64	0
-2.390	-2.770	141.19	72	0	-2.890	-2.675	311.04	120	0	-3.430	-2.580	918.59	248	0	-3.930	-2.485	350.00	56	0
-2.375	-3.290	186.08	80	0	-2.865	-3.185	400.00	128	0	-3.390	-3.080	794.08	224	0	-3.880	-2.975	448.00	56	0
-2.360	-3.740	214.92	72	0	-2.840	-3.635	533.38	128	0	-3.350	-3.530	921.12	152	0	-3.830	-3.425	622.22	56	0
-2.340	-4.240	228.59	56	0	-2.840	-4.135	624.30	136	0	-3.350	-4.030	1113.09	128	0	-3.830	-3.925	738.48	48	0
-2.320	-4.620	250.00	40	0	-2.840	-4.520	945.46	104	0	-3.350	-4.420	1599.96	120	0	-3.830	-4.320	1400.00	56	0
-2.300	-5.000	444.44	40	0	-2.840	-4.905	1476.96	96	0	-3.350	-4.810	1920.00	96	0	-3.830	-4.715	2074.07	56	0
-2.280	-5.400	711.10	32	0	-2.840	-5.305	2057.11	72	0	-3.350	-5.210	1866.65	56	0	-3.830	-5.115	2500.00	40	0
-2.260	-5.850	1599.98	48	0	-2.840	-5.755	2560.00	64	0	-3.350	-5.660	2000.00	40	0	-3.830	-5.565	3636.36	40	0
-2.240	-6.300	2133.31	32	0	-2.840	-6.205	3333.32	40	0	-3.350	-6.110	3200.00	32	0	-3.830	-6.015	.00	48	0
-2.220	-6.700	.00	24	0	-2.840	-6.605	.00	40	0	-3.350	-6.510	.00	32	0	-3.830	-6.415	.00	32	0

	LINE NO.20					LINE NO.21			
-4.340	7.680	.00	32	0	-4.900	7.715	.00	40	0
-4.370	7.230	.00	40	0	-4.930	7.265	.00	60	0
-4.400	6.760	.00	40	0	-4.960	6.790	.00	56	0
-4.430	6.310	.00	40	0	-4.990	6.340	.00	56	0
-4.460	5.810	.00	48	0	-5.020	5.840	.00	32	0
-4.490	5.360	.00	40	0	-5.050	5.390	.00	48	0
-4.520	4.890	.00	32	0	-5.080	4.915	.00	40	0
-4.550	4.440	.00	40	0	-5.110	4.470	.00	48	0
-4.580	3.940	3636.36	40	0	-5.140	3.970	.00	56	0
-4.595	3.490	2400.00	48	0	-5.140	3.520	.00	40	0
-4.610	3.040	1500.00	48	0	-5.140	3.070	4666.65	56	0
-4.625	2.590	1021.30	48	0	-5.140	2.620	4580.84	68	0
-4.640	2.140	1107.72	72	0	-5.140	2.170	2560.00	64	0
-4.630	1.680	1000.00	80	0	-5.130	1.715	2060.64	80	0
-4.620	1.220	1204.34	112	0	-5.120	1.260	1626.54	64	0
-4.610	.780	1142.88	120	0	-5.110	.835	2095.19	68	0
-4.600	.340	904.39	104	0	-5.100	.415	1531.94	72	0
-4.600	-.120	1066.62	128	0	-5.105	-.085	905.66	48	0
-4.600	-.560	1152.00	144	0	-5.110	-.500	982.46	56	0
-4.600	-.970	1408.00	176	0	-5.115	-.905	1066.69	64	0
-4.600	-1.430	1466.61	176	0	-5.120	-1.355	627.57	48	0
-4.600	-1.910	1676.22	176	0	-5.120	-1.825	923.09	48	0
-4.600	-2.390	1832.40	160	0	-5.120	-2.300	1200.00	48	0
-4.600	-2.870	1600.04	104	0	-5.120	-2.770	1599.98	48	0
-4.600	-3.320	2666.64	120	0	-5.120	-3.220	2181.84	48	0
-4.600	-3.820	3999.96	120	0	-5.120	-3.720	2666.68	40	0
-4.600	-4.220	5200.00	104	0	-5.120	-4.120	4000.00	40	0
-4.600	-4.620	5714.32	80	0	-5.120	-4.525	.00	40	0
-4.600	-5.020	.00	80	0	-5.120	-4.925	.00	48	0
-4.600	-5.470	.00	56	0	-5.120	-5.375	.00	32	0
-4.600	-5.920	.00	64	0	-5.120	-5.825	.00	40	0
-4.600	-6.320	.00	40	0	-5.120	-6.225	.00	32	0

Figure 3-1. Processing Program - Output Example (continued)

```
      3  TAPE UNIT FOR 'GEG'           2  TAPE UNIT FOR 'PHOTO'          1  TAPE UNIT FOR 'PLOT'
      1  SC 4020 CAMERA NUMBER        10  BLANK GEG FRAMES ONLY        130  FRAMES PER PHOTO TAPE
    412  WORDS PER ID RECORD         704  WORDS PER DATA RECORD          9  FILTER ID WORD NUMBER
     50  MINIMUM ZERO RA VALUES       10  MINIMUM SC4020 X VALUE        10  MINIMUM SC4020 Y VALUE
   1013  MAXIMUM SC4020 X VALUE     1013  MAXIMUM SC4020 Y VALUE         5  DATA RECORDS PER ID REC
     16  WORDS PER PARAMETER CD.     608  PLOT OUTPUT BUFFER SIZE       22  RA COLUMNS PER FRAME
     32  DECLINATION ROWS              0  INPUT 'GEG' TAPES              0  'PHOTO' FILES SKIPPED
      8  PLOT DENSITY FACTOR           4  COURSE ERROR CORRECTION       20  PLOT OUTPUT BUFFERS
2000000  WORDS PER PLOT TAPE           0  1=PRINT RA AND DEC             0  1=PRINT FRAME DATA
      1  0=NO,1=BOX,2=0,3=0            1  1=PRINT CYCLE TIME            20  TITLE FRAME REPEATS
     20  Y RASTER FOR FRAME TITLE     70  X RASTER FOR FRAME TITLE     500  X RASTER FOR RA
   1020  Y RASTER FOR RA               3  X RASTER FOR DEC             500  Y RASTER FOR DEC
      1  X MAG. FOR RA,DEC             1  Y MAG. FOR RA,DEC             50  X,Y DISP. *100
     50  X CORR. *100                  1  X MAG. FOR GRID                1  Y MAG. FOR GRID
      2  DEG. BETWEEN MARKERS         15  DEGREES WIDTH                 20  DEGREES HEIGHT
     50  RASTER WIDTH *100            50  RASTER HEIGHT *100             0  STARS WERE INPUT

       FILTER          RAW LO        RAW HI        COR LO       COR HI
            1              20          3000           300        30000
            2              20          3000           300        30000
            3              20          3000           300        30000
            4              20          3000           300        30000
            5              20          3000           300        30000
            6              20          3000           300        30000
            7              20          3000           300        30000

START FLIK CYCLE
FRAME         1     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =    67169
FR=  1  DAY=337   SEC=  763   FIL=1   TA=  0
FRAME         2     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      131
FR=  2  DAY=337   SEC=  865   FIL=1   TA=  0
FRAME         3     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      130
FR=  3  DAY=337   SEC=  966   FIL=1   TA=  0
FRAME         4     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      131
FR=  4  DAY=337   SEC= 1067   FIL=1   TA=  0
FRAME         5     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      130
FR=  5  DAY=337   SEC= 1169   FIL=1   TA=  0
FRAME         6     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      131
FR=  6  DAY=337   SEC= 1270   FIL=1   TA=  0
FRAME         7     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      130
FR=  7  DAY=337   SEC= 1371   FIL=1   TA=  0
FRAME         8     2     12     15     20     2    16    20   3000   300  30000     1   704    1    0    0
ELAPSED SEC. =      130
FR=  8  DAY=337   SEC= 1473   FIL=1   TA=  0
```

Figure 3-2. Display Program - Output Example

4. DATA FORMATS

TELEMETRY DATA

Telemetered data can be simultaneously transmitted in realtime to various ground stations and recorded by two on-board tape recorders. Realtime transmissions are made at 64, 8, or 1 kilobits per second; tape recorded data (playback data) is recorded at 1 kilobit per second and transmitted to receiving stations at 64 kilobits per second. Realtime and playback transmissions are controlled by the ground stations.

Both realtime and playback data are telemetered in frames consisting of 128 9-bit words from two equipment groups, EG1 and EG2. EG1 usually controls realtime data; EG2 usually controls playback data. In telemetry from either group, gegenschein experiment data occupies words 11, 17, and 18 (refer to Figures 4-1 and 4-2).

Word 11 contains the filter number in the three most significant bits as shown below; the last six bits are not used.

f	f	f	0	0	0	0	0	0

where

fff = filter wheel position as follows:

100	calibrate position
101	filter #1: green
001	filter #2: green polarized
011	filter #3: green polarized
010	filter #4: infrared
110	filter #5: ultraviolet
111	no sun
000	experiment off

Words 17 and 18 contain the intensity value for a single picture element and the raster line number in the following format:

Word 17									Word 18								
i	i	i	i	i	i	i	i	i	i	i	i	L	L	L	L	L	0

where

i = 12-bit element intensity value in the binary equivalent of decimal numbers in the arithmetic progression 0, 8, 16, 32... 32760.

L = line of scan (0 to 21).

HORIZONTAL MATRIX LINES / VERTICAL MATRIX LINES

	KI01	KI02	KI03	KI04	KI05	KI06	KI07	KI08	KI09	KI10	KI11	KI12	KI13	KI14	KI15	KI16
RI1	1 / 000 SYNC WORD #1	2 / 001 SYNC WORD #2	3 / 002 SYNC WORD #3	4 / 003 **2** SOEP 2 PROBE, OUTPUT 1	5 / 004 **2** SOEP 2 PROBE OUTPUT 2	6 / 005 **2** SOEP 2 PROBE, OUTPUT 3	7 / 006 **2** SOEP 2 PROBE, OUTPUT 4	8 / 007 **18** RECEIVER IF VOLTAGE	9 / 010 **13** SENSOR CONTROLS AND DATA	10 / 011 **3** PROTON CUP DATA AND MONITORS	11 / 012 **20** FILTER NUMBER	12 / 013 **13** SENSOR CONTROLS AND DATA	13 / 014 **5** ELECTROMETER OUTPUT	14 / 015 **10** X AXIS WAVEFORM	15 / 016 **10** Y AXIS WAVEFORM	16 / 017 **10** Z AXIS WAVEFORM
RI2	17 / 020 **20** LIGHT INTENSITY	18 / 021 **20** INTENSITY AND SCAN LINE NO	19 / 022 **7** D1 PULSE HEIGHT DATA	20 / 023 **7** D4 RATE DATA	21 / 024 **2** OPEP 2 PROBE 1 OUTPUT	22 / 025 **2** OPEP 2 PROBE 2 OUTPUT	23 / 026 **2** HIGH VOLTAGE READOUT	24 / 027 **15** 1-6 AMU 10[illegible] CURRENT DATA	25 / 030 **5** PARTICLE COUNT	26 / 031 **18** RECEIVER IF VOLTAGE	27 / 032 **15** 1-6 AMU 10[illegible] CURRENT DATA	28 / 033 **7** COMBINATION RATE DATA	29 / 034 **7** [illegible] RATE DATA	30 / 035 **11** FLUXGATE COIL A, -30 TO +30 GAMMA	31 / 036 **11** FLUXGATE COIL B, -30 TO +30 GAMMA	32 / 037 **11** FLUXGATE COIL C, -30 TO +30 GAMMA
RI3	33 △ 040 ACCUMULATED TIME (SECS)	34 / 041	35 / 042	36 / 043 **3** ELECTRON CUP DATA AND MONITORS	37 / 044 **10** X AXIS WAVEFORM	38 / 045 **10** Y AXIS WAVEFORM	39 / 046 **10** Z AXIS WAVEFORM	40 / 047 **15** 1-6 AMU 10[illegible] CURRENT DATA	41 / 050 **13** SENSOR CONTROLS AND DATA	42 / 051 **3** PROTON CUP DATA AND MONITORS	43 / 052 **9** ION CHAMBER DATA	44 / 053 **13** SENSOR CONTROLS AND DATA	45 / 054 **18** RECEIVER IF VOLTAGE	46 / 055 **17** 0.2-1.6 KC RECEIVER OUTPUT	47 / 056 **17** 1.6-12.5 KC RECEIVER OUTPUT	48 / 057 **17** 12.5-100 KC RECEIVER OUTPUT
RI4	49 / 060 **7** D1 PULSE HEIGHT DATA	50 / 061 **7** D3 PULSE HEIGHT DATA	51 / 062 **7** D4 PULSE HEIGHT DATA	52 / 063 **7** COMBINATION RATE DATA	53 / 064 **7** D4 RATE DATA	54 / 065 **15** 1-6 AMU 10[illegible] CURRENT DATA	55 / 066 **4** A PULSE HEIGHT DATA	56 / 067 **4** B PULSE HEIGHT DATA	57 / 070 **4** PULSE COUNT	58 / 071 **6** A PULSE HEIGHT DATA	59 / 072 **6** B PULSE HEIGHT DATA	60 / 073 **6** EVENTS COUNT BOTH TELESCOPES	61 / 074 **10** X AXIS WAVEFORM	62 / 075 **10** Y AXIS WAVEFORM	63 / 076 **10** Z AXIS WAVEFORM	64 / 077 **18** RECEIVER IF VOLTAGE
RI5	65 / 100 [illegible]	66 / 101 [illegible]	67 / 102 [illegible]	68 / 103 **15** 1-6 AMU 10[illegible] CURRENT DATA	69 / 104 **15** 7-45 AMU 10[illegible] CURRENT DATA	70 / 105 **15** 7-45 AMU 10[illegible] CURRENT DATA	71 / 106 **15** 7-45 AMU 10[illegible] CURRENT DATA	72 / 107 **15** 7-45 AMU 10[illegible] CURRENT DATA	73 / 110 **13** SENSOR CONTROLS AND DATA	74 / 111 **3** PROTON CUP DATA AND MONITORS	75 / 112 **OPEP 2** SHAFT POSITION	76 / 113 **13** SENSOR CONTROLS AND DATA	77 / 114 **5** ELECTROMETER OUTPUT	78 / 115 **19** ION CHAMBERS A B C COMBINED OUTPUT	79 / 116 **19** ION CHAMBER D OUTPUT	80 / 117 **10** Z AXIS 10 CPS
RI6	81 / 120 **1** PULSE HEIGHT DATA	82 / 121 **1** PULSE HEIGHT DATA	83 / 122 **1** PULSE HEIGHT DATA	84 / 123 **1** PULSE HEIGHT DATA	85 / 124 **18** RECEIVER IF VOLTAGE	86 / 125 **10** X AXIS WAVEFORM	87 / 126 **10** Y AXIS WAVEFORM	88 / 127 **10** Z AXIS WAVEFORM	89 / 130 **5** PARTICLE COUNT	90 / 131 **9** ION CHAMBER DATA	91 / 132 **11** FLUXGATE COIL A, -500 TO +500 GAMMA	92 / 133 **11** FLUXGATE COIL B, -500 TO +500 GAMMA	93 / 134 **11** FLUXGATE COIL C, -500 TO +500 GAMMA	94 / 135 **11** FLUXGATE COIL A, -30 TO +30 GAMMA	95 / 136 **11** FLUXGATE COIL B, -30 TO +30 GAMMA	96 / 137 **11** FLUXGATE COIL C, -30 TO +30 GAMMA
RI7	97 / 140 SUBCOM 1 DATA WORD HERE	98 / 141 SUBCOM 2 DATA WORD HERE	99 / 142 SUBCOM 3 DATA WORD HERE	100 / 143 **9** ION CHAMBER ELECTROMETER OUTPUT	101 / 144	102 / 145 **11** Rb VAPOR MAGNETOMETER DATA	103 / 146 **18** RECEIVER IF VOLTAGE	104 / 147 **5** ABSORBER WHEEL POSITION	105 / 150 **13** SENSOR CONTROLS AND DATA	106 / 151 **3** PROTON CUP DATA AND MONITORS	107 / 152 **3** ELECTRON CUP DATA AND MONITORS	108 / 153 **13** SENSOR CONTROLS AND DATA	109 / 154 **15** 7-45 AMU 10[illegible] CURRENT DATA	110 / 155 **17** 0.2-1.6 KC RECEIVER OUTPUT	111 / 156 **17** 1.6-12.5 KC RECEIVER OUTPUT	112 / 157 **17** 12.5-100 KC RECEIVER OUTPUT
RI8	113 / 160 **9** ION CHAMBER DATA	114 / 161 **8** PARTICLE COUNT 2^8 TO 2^{14}	115 / 162 **8** PARTICLE COUNT 2^0 TO 2^7	116 / 163 **9** ELECTRON SPECTROMETER DATA	117 / 164 **10** X AXIS WAVEFORM	118 / 165 **10** Y AXIS WAVEFORM	119 / 166 **10** Z AXIS WAVEFORM	120 / 167 **18** RECEIVER IF VOLTAGE	121 / 170 **9** ELECTRON SPECTROMETER DATA	122 / 171 **9** ELECTRON SPECTROMETER DATA	123 / 172 **9** ELECTRON SPECTROMETER DATA	124 / 173 **9** ELECTRON SPECTROMETER DATA	125 / 174 **12** ELECTRON SPHERE OUTPUT	126 / 175 **12** SPHERE VOLTAGE STATUS	127 / 176 **12** ION-PROTON SPHERE OUTPUT	128 / 177 **12** SWEEP BIAS AND ENERGY MODES

Figure 4-1. Main Telemetry Format - EG1

HORIZONTAL MATRIX LINES	KI01	KI02	KI03	KI04	KI05	KI06	KI07	KI08
RI1	1 / 000 SYNC WORD #1 000 110 010	2 / 001 SYNC WORD #2 011 111 000	3 / 002 SYNC WORD #3 101 011 010	4 / 003 2 SOEP 2 PROBE, OUTPUT 1	5 / 004 2 SOEP 2 PROBE, OUTPUT 2	6 / 005 2 SOEP 2 PROBE, OUTPUT 3	7 / 006 2 SOEP 2 PROBE, OUTPUT 4	8 / 007 18 RECEIVER IF VOLTAGE
RI2	17 / 020 20 LIGHT INTENSITY	18 / 021 20 INTENSITY AND SCAN LINE NO	19 / 022 7 D1 PULSE HEIGHT DATA	20 / 023 7 D4 RATE DATA	21 / 024 2 OPEP 2 PROBE 1 OUTPUT	22 / 025 2 OPEP 2 PROBE 2 OUTPUT	23 / 026 2 HIGH VOLTAGE READOUT	24 / 027 15 1-6 AMU 10^{-10} CURRENT DATA
RI3	33 △ 040 ACCUMULATED TIME (SECS) 2^{23} — 2^{16}	34 / 041 2^{15} — 2^{8}	35 / 042 2^{7} — 2^{0}	36 / 043 3 ELECTRON CUP DATA AND MONITORS	37 / 044 10 X AXIS WAVEFORM	38 / 045 10 Y AXIS WAVEFORM	39 / 046 10 Z AXIS WAVEFORM	40 / 047 15 1-6 AMU 10^{-12} CURRENT DATA
RI4	49 / 060 7 D1 PULSE HEIGHT DATA	50 / 061 7 D3 PULSE HEIGHT DATA	51 / 062 7 D4 PULSE HEIGHT DATA	52 / 063 7 COMBINATION RATE DATA	53 / 064 7 D4 RATE DATA	54 / 065 15 1-6 AMU 10^{-13} CURRENT DATA	55 / 066 4 A PULSE HEIGHT DATA	56 / 067 4 B PULSE HEIGHT DATA
RI5	65 / 100 2^5 … 2^0 SUBCOM WORD NUMBER THIS FRAME	66 / 101 EMITTED EG 2^4 … 2^0 FF NO	67 / 102 OTHER EG 2^4 … 2^0 FF NO	68 / 103 15 1-6 AMU 10^{-14} CURRENT DATA	69 / 104 15 7-45 AMU 10^{-10} CURRENT DATA	70 / 105 15 7-45 AMU 10^{-11} CURRENT DATA	71 / 106 15 7-45 AMU 10^{-12} CURRENT DATA	72 / 107 15 7-45 AMU 10^{-13} CURRENT DATA
RI6	81 / 120 1 PULSE HEIGHT DATA	82 / 121 1 PULSE HEIGHT DATA	83 / 122 1 PULSE HEIGHT DATA	84 / 123 1 PULSE HEIGHT DATA	85 / 124 18 RECEIVER # VOLTAGE	86 / 125 10 X AXIS WAVEFORM	87 / 126 10 Y AXIS WAVEFORM	88 / 127 10 Z AXIS WAVEFORM
RI7	97 / 140 SUBCOM 1 DATA WORD HERE	98 / 141 SUBCOM 2 DATA WORD HERE	99 / 142 SUBCOM 3 DATA WORD HERE	100 / 143 15 1-6 AMU 10^{-9} CURRENT DATA	101 / 144 15 7-45 AMU 10^{-9} CURRENT DATA	102 / 145 11 R_b VAPOR MAGNETOMETER DATA	103 / 146 18 RECEIVER IF VOLTAGE	104 / 147 5 ABSORBER WHEEL POSITION
RI8	113 / 160 9 ION CHAMBER DATA	114 / 161 8 PARTICLE COUNT 2^8 TO 2^{15}	115 / 162 8 PARTICLE COUNT 2^0 TO 2^7	116 / 163 9 ELECTRON SPECTROMETER DATA	117 / 164 10 X AXIS WAVEFORM	118 / 165 10 Y AXIS WAVEFORM	119 / 166 10 Z AXIS WAVEFORM	120 / 167 18 RECEIVER IF VOLTAGE

HORIZONTAL MATRIX LINES	KI09	KI10	KI11	KI12	KI13	KI14	KI15	KI16
RI1	9 / 010 13 SENSOR CONTROLS AND DATA	10 / 011 3 PROTON CUP DATA AND MONITORS	11 / 012 20 FILTER NUMBER	12 / 013 13 SENSOR CONTROLS AND DATA	13 / 014 5 ELECTROMETER OUTPUT	14 / 015 10 X AXIS WAVEFORM	15 / 016 10 Y AXIS WAVEFORM	16 / 017 10 Z AXIS WAVEFORM
RI2	25 / 030 5 PARTICLE COUNT	26 / 031 18 RECEIVER # VOLTAGE	27 / 032 15 1-6 AMU 10^{-11} CURRENT DATA	28 / 033 7 COMBINATION RATE DATA	29 / 034 7 D5 RATE DATA	30 / 035 11 FLUXGATE COIL A, -30 TO +30 GAMMA	31 / 036 11 FLUXGATE COIL B, -30 TO +30 GAMMA	32 / 037 11 FLUXGATE COIL C, -30 TO +30 GAMMA
RI3	41 / 050 13 SENSOR CONTROLS AND DATA	42 / 051 3 PROTON CUP DATA AND MONITORS	43 / 052 9 ION CHAMBER DATA	44 / 053 13 SENSOR CONTROLS AND DATA	45 / 054 18 RECEIVER # VOLTAGE	46 / 055 17 0.2-1.6 KC RECEIVER OUTPUT	47 / 056 17 1.6-12.5 KC RECEIVER OUTPUT	48 / 057 17 12.5-100 KC RECEIVER OUTPUT
RI4	57 / 070 4 PULSE COUNT	58 / 071 6 A PULSE HEIGHT DATA	59 / 072 6 B PULSE HEIGHT DATA	60 / 073 6 EVENTS COUNT - BOTH TELESCOPES	61 / 074 10 X AXIS WAVEFORM	62 / 075 10 Y AXIS WAVEFORM	63 / 076 10 Z AXIS WAVEFORM	64 / 077 18 RECEIVER # VOLTAGE
RI5	73 / 110 13 SENSOR CONTROLS AND DATA	74 / 111 3 PROTON CUP DATA AND MONITORS	75 / 112 OPEP 2 SHAFT POSITION	76 / 113 13 SENSOR CONTROLS AND DATA	77 / 114 5 ELECTROMETER OUTPUT	78 / 115 19 ION CHAMBERS A,B,C COMBINED OUTPUT	79 / 116 19 ION CHAMBER D OUTPUT	80 / 117 10 Z AXIS 10 CPS
RI6	89 / 130 5 PARTICLE COUNT	90 / 131 9 ION CHAMBER DATA	91 / 132 11 FLUXGATE COIL A, -500 TO +500 GAMMA	92 / 133 11 FLUXGATE COIL B, -500 TO +500 GAMMA	93 / 134 11 FLUXGATE COIL C, -500 TO +500 GAMMA	94 / 135 11 FLUXGATE COIL A, -30 TO +30 GAMMA	95 / 136 11 FLUXGATE COIL B, -30 TO +30 GAMMA	96 / 137 11 FLUXGATE COIL C, -30 TO +30 GAMMA
RI7	105 / 150 13 SENSOR CONTROLS AND DATA	106 / 151 3 PROTON CUP DATA AND MONITORS	107 / 152 3 ELECTRON CUP DATA AND MONITORS	108 / 153 13 SENSOR CONTROLS AND DATA	109 / 154 15 7-45 AMU 10^{-14} CURRENT DATA	110 / 155 17 0.2-1.6 KC RECEIVER OUTPUT	111 / 156 17 1.6-12.5 KC RECEIVER OUTPUT	112 / 157 17 12.5-100 KC RECEIVER OUTPUT
RI8	121 / 170 9 ELECTRON SPECTROMETER DATA	122 / 171 9 ELECTRON SPECTROMETER DATA	123 / 172 9 ELECTRON SPECTROMETER DATA	124 / 173 9 ELECTRON SPECTROMETER DATA	125 / 174 12 ELECTRON SPHERE OUTPUT	126 / 175 12 SPHERE VOLTAGE STATUS	127 / 176 12 ION-PROTON SPHERE OUTPUT	128 / 177 12 SWEEP, BIAS AND ENERGY MODES

VERTICAL MATRIX LINES

Figure 4-2. Main Telemetry Format - EG2

DECOM TAPE

The Decom Tape format is shown in Figures 4-3, 4-4, and 4-5. The tape may contain up to nine files; each file contains the data received at a data acquisition station during the spacecraft's pass over that station.

Character	Description
1-5+Space	Satellite Identification (assigned after launch) Example: 66491 where: 66 = year of launch 49 = numbered launches from start of year 1 = object
7-8+Space	Year
10-12+Space	Station Number. Example:001 = Blossom Point 020 = Rosman
14-15+Space	Analog File Number.
17-20+Space	Analog Tape Number.
22-23+Space	Buffer File Number.
25-28+Space	Buffer Tape Number.
30-32+Space	Date of data digitization (day of year).
34-66	Will be identical to character 1-33 unless an error was found in those characters. If that is the case, then this portion of the record will contain the corrected values of that field.
67+Space	Type of data contained in file: 0 = 1 kilobit real time 1 = 8 kilobit real time 2 = 64 kilobit real time 3 = command storage playback
69-71	Day of year.
73-77+Space	Seconds of day; start time of data.

Figure 4-3. Decom Tape Format: Label Record

Character	Description
79+Space	Is Flexible Format in use? 1 = Yes 0 = No
81-82	Flexible Format Number
83-88	Blank
89+Space	Equipment Group in use (1 or 2)
91-94+Space	Master Binary Tape Number
96-97+Space	Master Binary File Number
99-100+Space 102-103	A/D line operator ID A/D line ID
104-113	Blank
114-115	Reel Sequence Number
116-118	Run Number
119-120	Experiment Number

Figure 4-3. Decom Tape Format: Label Record (continued)

Tele. Group			
S/C Word	Frame Number	Character	Description
		1-6	Time field: milliseconds of day (GMT) for the first bit of S/C word #1.
		7-8	Day count of year.
98	23	9-10	Yaw error signal.
98	24	11-12	Array error signal.
99	30	13-14	SOEP #1 (-y face).
99	37	15-16	Temperature of body near module #13.
98	47	17-18	Load Bus Voltage.
66	1	19-20	ID word (once per subcom sequence): Bit — Item 1 — Data Type 2-4 — Mode 5-9 — Flexible Format No.
67	1	21-22	ID word - same as above.
99	40	23-24	SOEP #1 (+y face).
		25-30	Spare characters.
		31-32+18N	Frame status field (see Figure 4-5).
33	N	33-34+18N	Spacecraft accumulated time in seconds.
34	N	35-36+18N	
35	N	37-38+18N	
65	N	39-40+18N	Data identification word: Bit — Item 1-7 — Subcom position 8 — Execute relay state 9 — Cross strap
11	N	41-42+18N	Digital experiment data.
17	N	43-44+18N	
18	N	45-46+18N	
		47-48+18N	Flag signifying end.

N = 0, 1, 2, . . . 126, 127

Figure 4-4. Decom Tape Format: Data Records

Bit**	State	Representation for F1, Quality Control Status*
1-6		Total bit errors in the 27 bit frame sync word.
7	1	This frame is fill data.
8	1	This frame is the beginning of a subcom sequence.
9 10	0 0	This frame contains 1 kilobit real time data.
9 10	1 0	This frame contains 8 kilobit real time data.
9 10	0 1	This frame contains 64 kilobit real time data.
9 10	1 1	This frame contains command storage playback data.
11	1	This frame contains suspect data. This flag will appear when the bit errors in the frame sync word are ≥ 3.
12	1	This frame contains corrected time.

*Computer determined.
**Bit 12 is most significant bit; bit one is least significant bit.

Figure 4-5. Decom Tape Format: Quality Status Fields

ATTITUDE TAPE

The Attitude Tape format is shown in Figures 4-6 and 4-7; Figure 4-8 defines the terminology used in the format definitions. The tape contains one file (a 250-word label record and 250-word data records) for each orbit. After the EOF following the last data record, there is a 250-word record of floating point nines (99999999.0), which is followed by an EOF.

Word	Units	Symbol	Function or Name	Description, Notes
1	none	ID	Identification	
2 3 4	year month day		Start time of orbit	Greenwich Mean Time (GMT); also called Universal Time.
5 6	day msec. of day	tE1	Eclipse start	Start time of eclipse in GMT.
7 8	day msec. of day	tE2	Eclipse end	End time of eclipse in GMT.
9 10	day msec. of day	tO1	Orbit start	Start time of orbit (time of the ascending node). The ascending node is that point in the equatorial plane through which the satellite passes while going from south to north. See Figure 4-8 (c).
11 12	day msec. of day	tO2	Orbit end	End time in GMT of this orbit and start time of the next orbit (time of the next ascending node). See Figure 4-8 (c).

Figure 4-6. Attitude Tape Format: Label Record

Word	Units	Symbol	Function or Name	Description, Notes
13 14	day msec. of day	tn	Noon turn	Time in GMT of predicted noon turn. The paddles are only able to rotate through 180^o. When the paddles are looking straight up ($\varphi_p = 270^o$) or straight down ($\varphi_p = 90^o$) at the sun, the spacecraft turns 180^o about the body Z axis, so the paddle may reverse its direction of rotation and still continue to follow the sun. See data record word 121.
15 16	day msec. of day	τ	Epoch	The arbitrary reference time in GMT at which the orbital elements were computed.
17	msec.	Δt	Sampling rate	The values in the data records are given at intervals of $t_a + \Delta t$. The value of Δt is expected to be 60,000 milliseconds (1 min).
18	none		Orbit number	Orbit zero is from launch to the first ascending node. Orbit one starts at the first ascending node and ends at the second ascending node. The nth orbit starts at the nth ascending node. See Figure 4-8 (c).
19	earth radii	a	Semi-major axis	The semi-major axis of the orbital ellipse (1 earth radius = 6371.2 km). See Figure 4-8 (a).

Figure 4-6. Attitude Tape Format: Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
20	none	e	Eccentricity	The eccentricity of the orbital ellipse. See Figure 4-8 (a).
21	degrees	i	Inclination	The angle of the orbital plane and the earth's equatorial plane. See Figure 4-8 (b).
22	degrees	Ω	Longitude of ascending node	The angle between the Geocentric Equatorial Inertial (GEI) X axis (γ) and the position vector of the ascending node. See Figure 4-8 (d).
23	degrees/ day	$\dot{\Omega}$		Rate of change of Ω.
24	degrees	ω	Argument of perigee	Perigee is that orbital point which is nearest the earth. ω is the angle between the position vector of the ascending node and the position vector of perigee. See Figure 4-8 (c).
25	degrees/ day	$\dot{\omega}$		Rate of change of ω.
26	minutes	T	Period	The time required to make one orbit.
27	minutes/ day	$\dot{T}$		Rate of change of T.
28-99				Spares

Figure 4-6. Attitude Tape Format Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
100	degree/sec.	r	Spin rate	If the spacecraft is spinning about an axis which is stabilized with respect to the craft, the spin rate, r, is given as a positive number.
101	degrees/ sec./day	$\dot{r}$		Rate of change of r.
102-104	none	A	GEI spin axis	A = (Ax, Ay, Az) and is the spin axis as a unit vector in GEI coordinates A is defined so the spin rate, r, is positive with respect to the right-hand rule.
105-107	none	Ab	Body spin axis	Ab = (Abx, Aby, Abz) is the spin axis as a unit vector represented in body coordinates. This representation will not change when the spin axis is stabilized with respect to the spacecraft.
108-116	none	R1	First spin matrix	In each of R1, R2, and R3, the first three words contain the values in the top row of the matrix, the second three words contain the values in the middle row of the matrix,
117-125		R2	Second spin matrix	
126-134		R3	Third spin matrix	

Figure 4-6. Attitude Tape Format: Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
				and the last three words contain the bottom row of the matrix. Let: $b(T_1) = \begin{bmatrix} bXx & bYx & bZx \\ bXy & bYy & bZy \\ bXz & bYz & bZz \end{bmatrix}$ where bXx through bZz are defined in data record words 49-57, i.e., bx, by, and bz at T_1 where T_1 is defined in word 1 of the data record. Now let $\bar{b}(T)$ be the interpolation of $b(T_1)$ to time T with no correction for spin. Then: $b(T) = \bar{b}(T)\ R1 + \bar{b}(T)\ R2 \sin \sigma\ (T)$ $+ b(T)\ R2 \cos \sigma\ (T)$ $= \bar{b}(T) \mid R1 + R2 \sin \sigma\ (T) + R3$ $\cos \sigma\ T \mid$ where b(T) defines the body coordinate axes in GEI coordinates, as in $b(T_1)$, and σ (T) is the angle from the spin vector $A(T_1) = (Ax, Ay, Az)$ at time T_1 to spin vector A(T) at time T.
135-250				Spares

Figure 4-6. Attitude Tape Format: Label Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
1	days	T1	Time	Day count.
2	msec.			Milliseconds of day in Greenwich Mean Time (GMT). All data in this record corresponds to T_1.
3 4 5	hours minutes tenths of minutes	TL	Local Time	Local Apparent Solar Time of subsatellite point.
6	degrees	α	Right ascension	The angle from the first point of Aries (γ) to the equatorial plane projection of the spacecraft position vector. See Figure 4-8 (e).
7	degrees	δ	Declination	The angle from the equatorial plane projection of the spacecraft position vector to the spacecraft position vector. See Figure 4-8 (e).
8-10	kilometers	P	Position vector	P = (Px, Py, Pz) is the position vector of the spacecraft in Geocentric Equatorial Inertial (GEI) coordinates (also known as Universal coordinates). See Figure 4-8 (e).
11-13	kilometers/sec.	V	Velocity vector	V = (Vx, Vy, Vz) is the direction and magnitude of the spacecraft velocity in GEI coordinates. See Figure 4-8 (e).
14-16	kilometers	S	Solar vector	S = (Sx, Sy, Sz) is the position vector of the sun in GEI coordinates.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
17	degrees	φ	Latitude	Geodetic latitude of subsatellite point on the spheroid. North is +, South is -. The International Spheroid is used: a = semi-major axis = 6378.388 km f = flattening = 297. = a/a-b.
18	degrees	λ	Longitude	Geodetic longitude of subsatellite point on the spheroid. East is +, West is -.
19	kilometers	h	Height	Height of satellite above the spheroid. See Figure 4-8 (e).
20	degrees	ν	True anomaly	Orbital central angle between perigee and satellite with earth as focus. See Figure 4-8 (a).
21	degrees	Φ	Sun earth satellite angle	The angle between the satellite position vector and the sun position vector.
22-24	none	bXI	Ideal body roll axis	bXI = (bXIx, bXIy, bXIz) is the ideal body X axis as a unit vector in GEI coordinates.
25-27	none	bYI	Ideal body pitch axis	bYI = (bYIx, bYIy, bXIz) is the ideal body Y axis as a unit vector in GEI coordinates.
28-30	none	bZI	Ideal body yaw axis	bZI = (bZIx, bZIy, bZIz) is the ideal body Z axis as a unit vector in GEI coordinates.
31-33	none	PXI	Ideal paddle roll axis	PXI = (PXIx, PXIy, PXIz) is the paddle X axis as a unit vector in GEI coordinates.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
34-36	none	PYI	Ideal paddle pitch axis	PYI = (PYIx, PYIy, PYIz) is the paddle Y axis as a unit vector in GEI coordinates.
37-39	none	PZI	Ideal paddle yaw axis	PZI = (PZIx, PZIy, PZIz) is the paddle Z axis as a unit vector in GEI coordinates.
40-42	none	EXI	OPEP ideal roll axis	EXI = (EXIx, EXIy, EXIz) is the OPEP X axis as a unit vector in GEI coordinates.
43-45	none	EYI	OPEP ideal pitch axis	EYI = (EYIx, EYIy, EYIz) is the OPEP Y axis as a unit vector in GEI coordinates.
46-48	none	EZI	OPEP ideal yaw axis	EZI = (EZIx, EZIy, EZIz) is the OPEP Z axis as a unit vector in GEI coordinates.
49-51	none	bX	Actual body roll axis	bX = (bXx, bXy, bXz) is the body X axis as a unit vector in GEI coordinates.
52-54	none	bY	Actual body pitch axis	bY = (bYx, bYy, bYz) is the body Y axis as a unit vector in GEI coordinates.
55-57	none	bZ	Actual body yaw axis	bZ = (bZx, bZy, bZz) is the body Z axis as a unit vector in GEI coordinates.
58-60	none	PX	Actual paddle roll axis	PX = (PXx, PXy, PXz) is the paddle X axis as a unit vector in GEI coordinates.
61-63	none	PY	Actual paddle pitch axis	PY = (PYx, PYy, PYz) is the paddle Y axis as a unit vector in GEI coordinates.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
64-66	none	PZ	Actual paddle yaw axis	PZ = (PZx, PZy, PZz) is the paddle Z axis as a unit vector in GEI coordinates.
67-69	none	EX	Actual OPEP roll axis	EX = (EXx, EXy, EXz) is the OPEP X axis as a unit vector in GEI coordinates.
70-72	none	EY	Actual OPEP pitch axis	EY = (EYx, EYy, EYz) is the OPEP Y axis as a unit vector in GEI coordinates.
73-75	none	EZ	Actual OPEP yaw axis	EZ = (EZx, EZy, EZz) is the OPEP Z axis as a unit vector in GEI coordinates.
76	earth radii	R	Magnetic range	$R = L \cos^2 (\varphi m)$ where L is the McIlwain parameter of the magnetic shell containing the spacecraft, and φm is the magnetic latitude of the spacecraft. Note that R is analogous to, but not equal to, $\|P\|$, the magnitude of the position vector.
77	degrees	φm	Magnetic latitude	The latitude of the spacecraft in geomagnetic coordinates. At the magnetic equator $\varphi m = 0$. See Figure 4-8 (f).
78	earth radii	L	McIllwain parameter	A magnetic shell parameter which is almost constant along lines of force. L is used to label each shell. In the ideal case (dipole field), L is the magnitude of the position vector on the magnetic equator of the line of force. See Figure 4-8 (f).

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
79	gamma	B	Field strength	The magnitude of magnetic field strength at the spacecraft. See Figure 4-8 (c).
80	none	B/B_0	Ratio	B is defined above. B_0 is the equatorial field strength of the shell. See Figure 4-8 (f).
81	degrees	φI	Ingress latitude	The latitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft enters the earth. See Figure 4-8 (f).
82	degrees	λI	Ingress longitude	The longitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft enters the earth. See Figure 4-8 (f).
83	degrees	φE	Egress latitude	The latitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft leaves the earth. See Figure 4-8 (f).
84	degrees	λE	Egress longitude	The longitude of the point on the surface of the earth at which the magnetic line of force passing through the spacecraft leaves the earth. See Figure 4-8 (f).
85-87	none	$\hat{B}$	B vector	$\hat{B}$ = (Bx, By, Bz) is the direction of the magnetic line of force expressed as a unit vector in the GEI system.

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
88-90	none	Bb	B Body	Bb = (Bbx, Bby, Bbz) is the unit direction vector, $\hat{B}$, expressed in the body coordinate system.
91-93	none	BP	B Paddle	BP = (BPx, BPy, BPz) is the unit direction vector, $\hat{B}$, expressed in the paddle coordinate system.
94-96	none	BE	B OPEP	BE = (BEx, BEy, BEz) is the unit direction vector, $\hat{B}$, expressed in the OPEP coordinate system.
97-99		B$\hat{B}$G	B$\hat{B}$ geodetic	BBG is the product of the field strength, B, times the unit vector, $\hat{B}$G = ($\hat{B}$GE, $\hat{B}$GN, $\hat{B}$GV), where ($\hat{B}$GE, $\hat{B}$GN, $\hat{B}$GV) is the unit vector, $\hat{B}$, expressed in geodetic coordinates. Note that this is a left-handed system instead of a right-handed system.
100-108	TGSE	GSE transformation		This is the transformation matrix which changes the GEI representation of a vector to GSE (Geocentric Solar Ecliptic) representation. The vector remains fixed. Words 100, 101, and 102 contain the values for the top row of the matrix, words 103, 104, and 105 contain the values for the middle row of the matrix, and words 106, 107, and 108 contain the values of the bottom row of the matrix.

Figure 4-7. Attitude Tape Format Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
				Any vector, v, in GEI is transformed by the relation V_{GSE} = (matrix) V_{GEI} = TGSE V_{GEI}
109-117	none	TGSM	GSM transformation	This is the transformation matrix which changes the GEI representation of a vector to GSM (Geocentric Solar Magnetic) representation. The vector remains fixed. Words 109, 110, and 111 contain the top row of the matrix, words 112, 113, and 114 contain middle row of the matrix, and words 115, 116 and 117 contain the bottom row of the matrix.
118-120	none	A	GEI spin axis	A = (Ax, Ay, Az) is the unit spin axis in GEI coordinates.
121		φP	Paddle angle	The paddle shaft angle is $\varphi P = 90^{\circ}$ when the paddle is looking in the direction of the body +Z axis (toward earth), it is $\varphi_P = 180^{\circ}$ when the paddle is looking in the -Y body axis direction (away from the OPEP), and $\varphi P = 270^{\circ}$ when the paddle is looking in the body -Z direction (away from the earth). Movement of the paddle is restricted such that $90^{\circ} \leq \varphi_P \leq 180^{\circ}$.

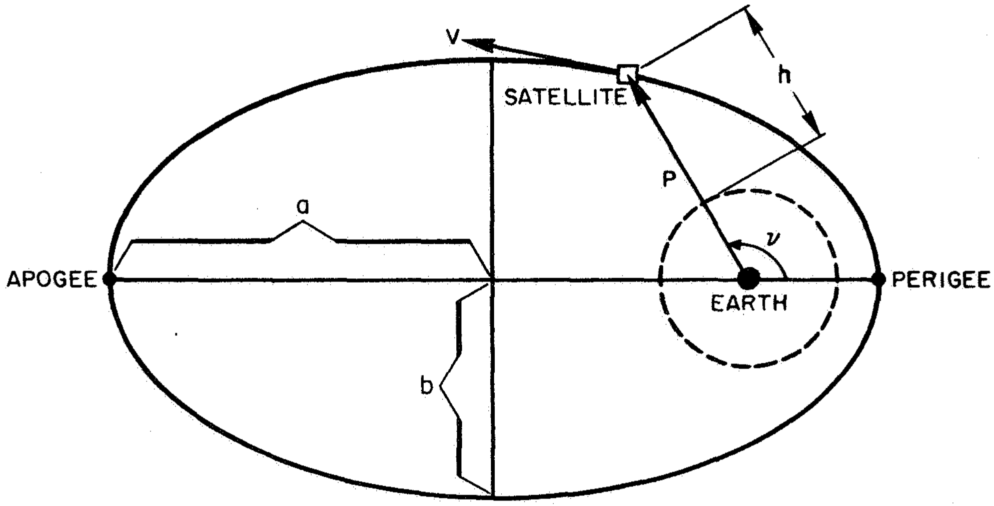
Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
122	degrees	ψE	OPEP angle	The OPEP shaft angle is $\psi E = 0$ when the OPEP is looking in the body +X direction (away from the spacecraft), and $\psi E = 90^o$ when the OPEP is looking in the body +Y direction (away from the spacecraft), and $\psi E = 270^o$ when the OPEP is looking in the body -Y direction (looking over the spacecraft). The OPEP can rotate through more than 360^o.
123	none	none	Attitude data flag	This flag is assigned the floating point value -1.0 if any housekeeping discrepancies are detected.
124		none	NO DATA flag	A value of 2^k or any combination of $2^{k1} \cdot 2^{k2} \ldots 2^{k5}$ in the NO DATA flag signifies that the data indicated by the flag was not available. The ideal value is used when the actual value is not available. The following table is used in words 124 and 125: bit value — data 2^0 — roll 2^1 — pitch 2^2 — yaw 2^3 — ψE = OPEP shaft angle 2^4 — φP = Paddle shaft angle 2^5 — Array error

Figure 4-7. Attitude Tape Format: Data Record (continued)

Word	Units	Symbol	Function or Name	Description, Notes
				(Note that word 124 is floating point.)
125	none	none	SUSPECT DATA flag	This word warns that the indicated data is of a suspected nature. The indications are the same as for word 124.
126	none	T2	Time	T2 = T1 + Δt and is defined the same as T1.
127-250	none			Defined the same as words 2-125 except that time T2 used.

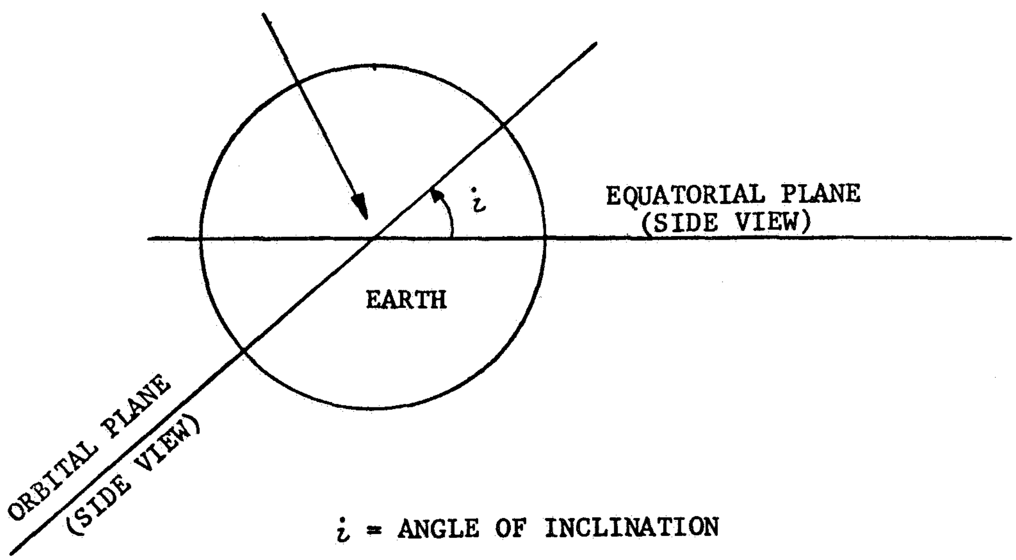
Figure 4-7. Attitude Tape Format: Data Record (continued)



$e = \sqrt{1 - b^2/a^2}$ = ECCENTRICITY
a = SEMI-MAJOR AXIS
b = SEMI-MINOR AXIS
P = POSITION VECTOR
V = VELOCITY VECTOR
ν = TRUE ANOMALY
h = HEIGHT OF SATELLITE

(a)

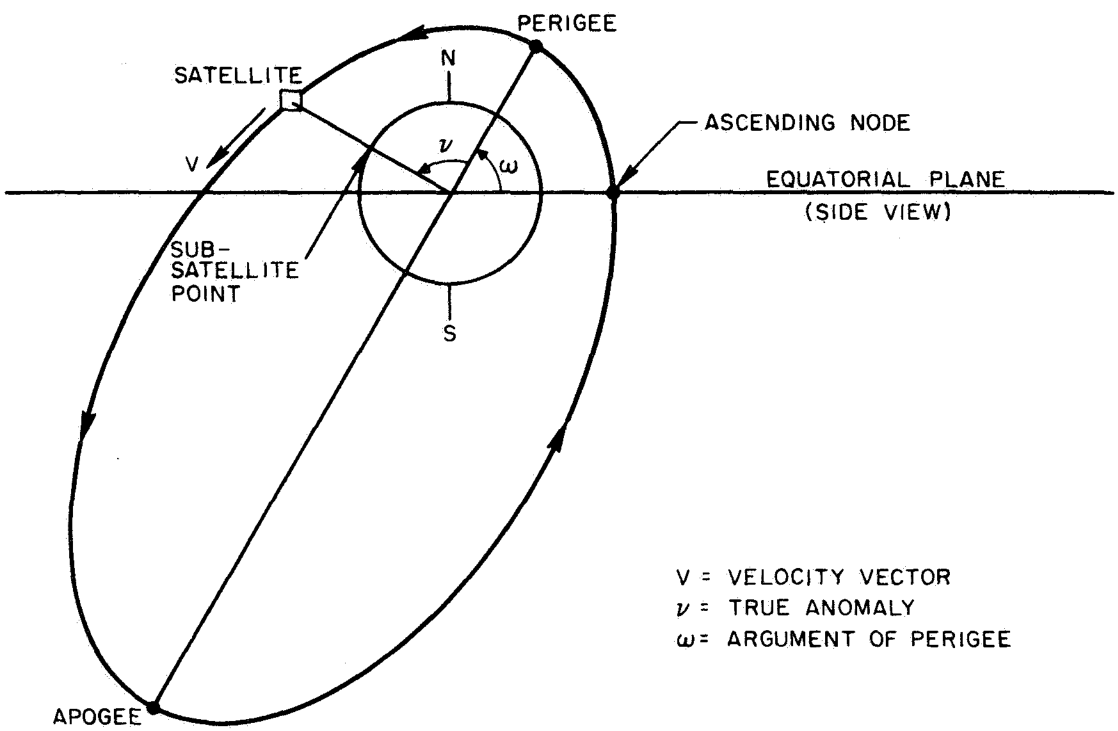
ASCENDING AND DESCENDING NODES



i = ANGLE OF INCLINATION

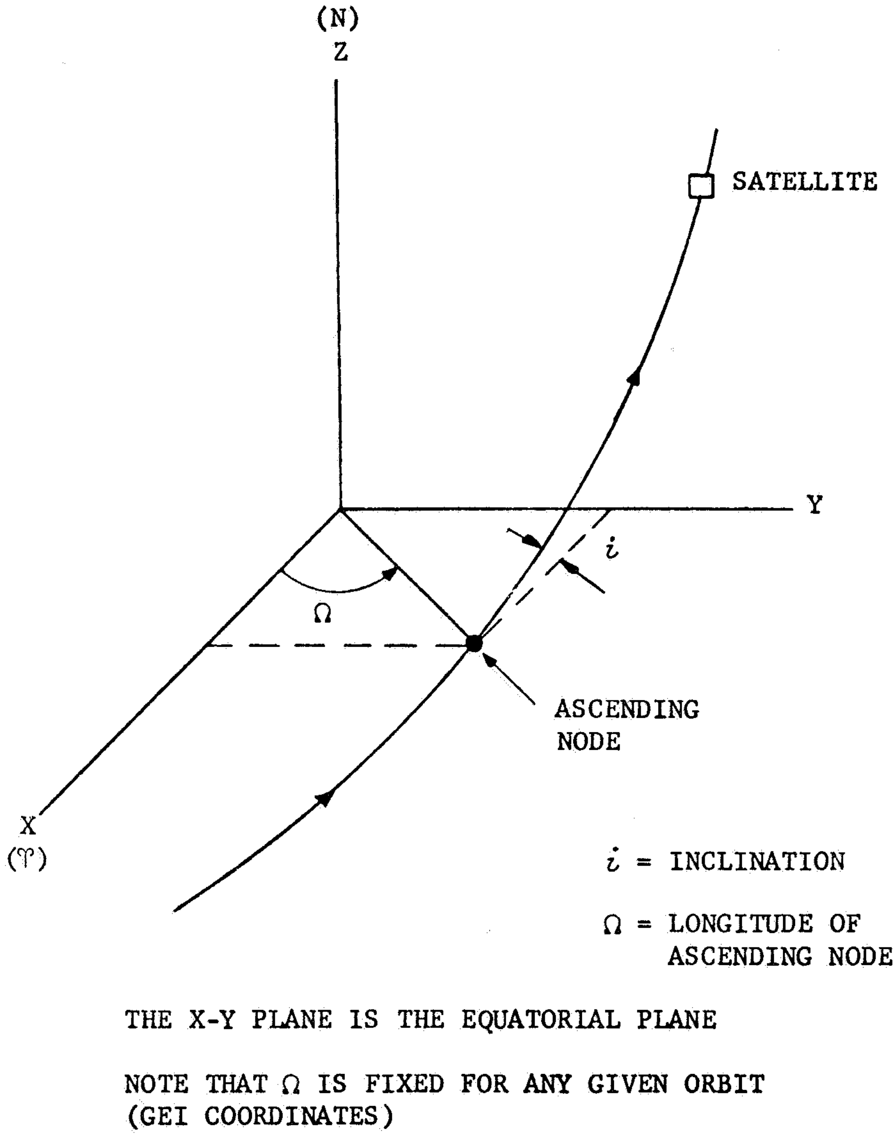
(b)

Figure 4-8 (a) and (b). Attitude Tape Format: Definitions



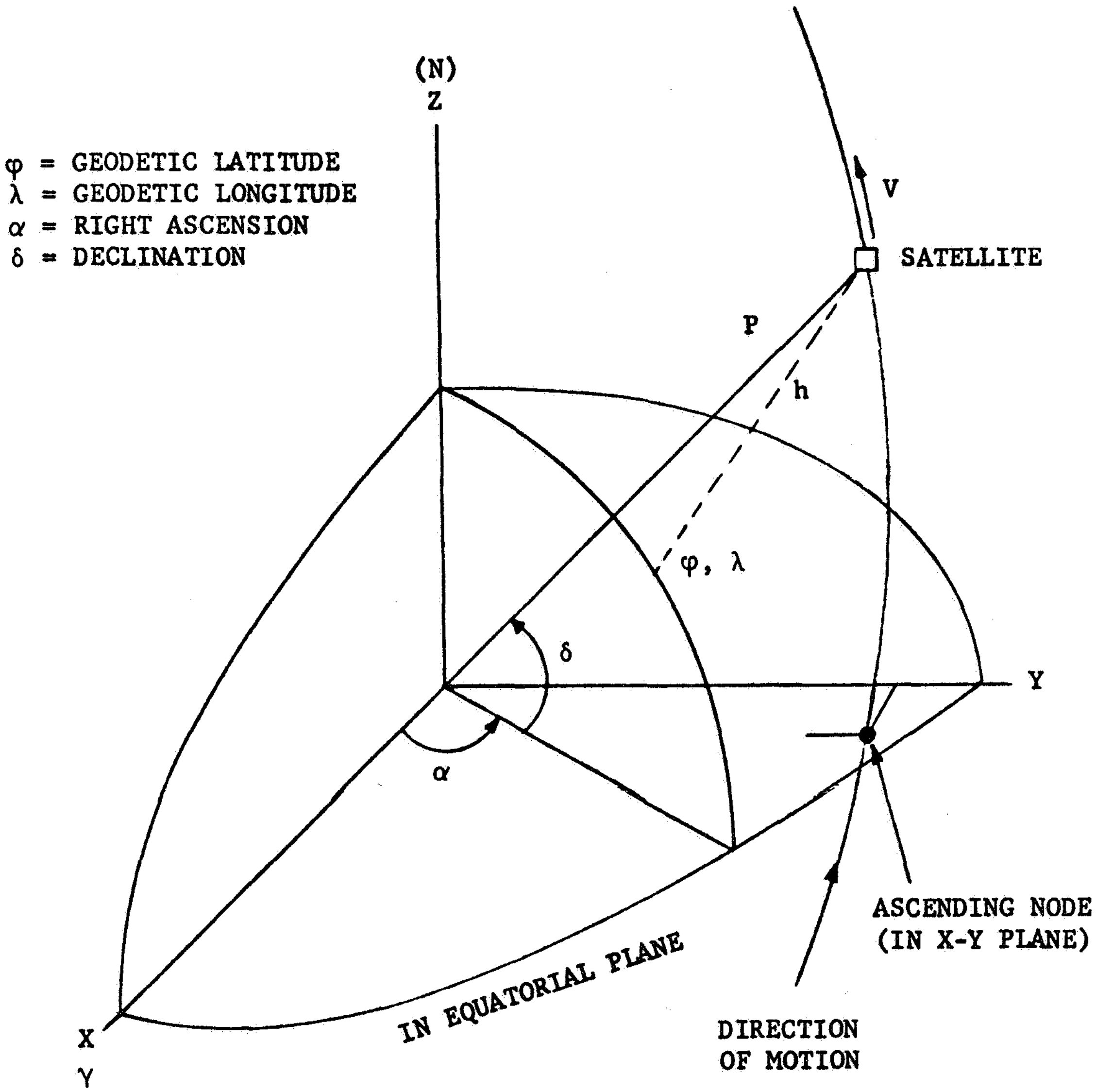
(c)

Figure 4-8 (c). Attitude Tape Format: Definitions



(d)

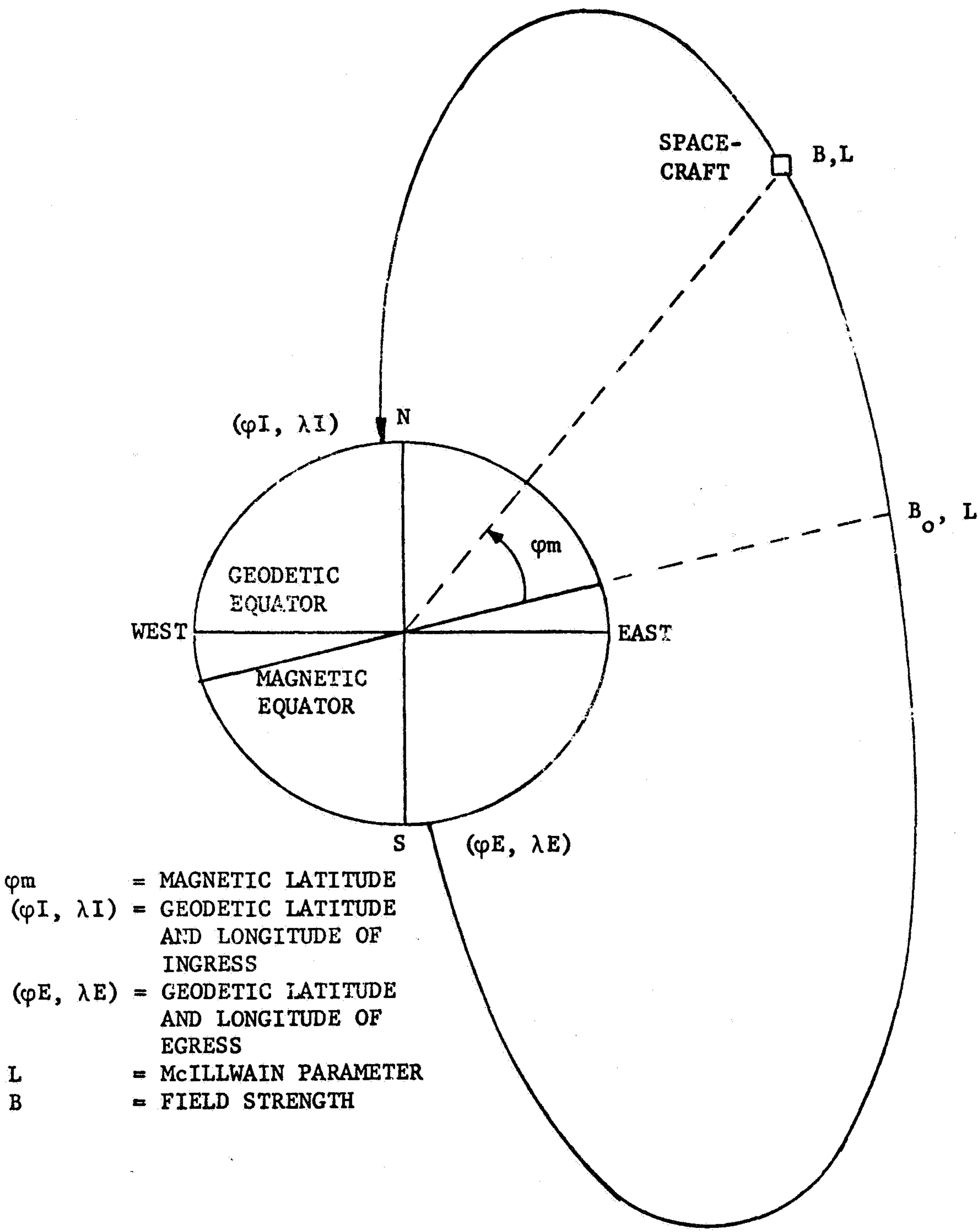
Figure 4-8 (d). Attitude Tape Format: Definitions



NOTE THAT α IS MEASURED FROM THE FIRST POINT ARIES (♈) WHICH IS FIXED, AND λ IS MEASURED FROM GREENWICH WHICH SPINS WITH THE EARTH.

(e)

Figure 4-8 (e). Attitude Tape Format: Definitions



(f)

Figure 4-8 (f). Attitude Tape Format: Definitions

GEGENSCHEIN DATA TAPES

The data tape contains five records per picture. The first record is a 412-character identification record. The remaining four records contain the picture data as shown in Figure 4-9.

	Word	Format	Contents
Identification Record - 412 Words	1	I	Begin time of picture (time of day).
	2	I	End time of picture (time of day).
	3	I	Time of yaw maneuver (day count of year).
	4	I	Time of yaw maneuver (time of day).
	5	I	Start time of eclipse (day count of year).
	6	I	Start time of eclipse (time of day).
	7	I	End time of eclipse (day count of year).
	8	I	End time of eclipse (time of day).
	9	I	Zero
	10	I	Accumulated satellite time.
	11	I	Temperature of SOEP Box #1 (-y) (raw value).
	12	I	Satellite identification.
	13	I	Year
	14	I	Station number.
	15	I	Analog tape number.
	16	I	Buffer tape number.
	17	I	Date of digitalization.
	18	I	Temperature of body package.
	19	I	Equipment group number.
	20	I	Binary tape number.
	21	I	Binary file number.
	22	I	Bit rate.
	23	I	Begin time of picture (day count of year).
	24	I	End time of picture (day count of year).

Figure 4-9. Gegenschein Data Tape Format

ID Record (continued)	25	I	Load bus voltage (raw value).
	26	FP	Yaw error (engineering units).
	27	FP	Array error (engineering units).
	28	FP	Temperature of SOEP Box #1 (-y) (engineering units).
	29	FP	Temperature of SOEP Box #1 (+y) (raw value).
	30	FP	Temperature of SOEP Box #1 (engineering units).
	31	FP	Temperature of Body Package (engineering units).
	32	I	Yaw error (raw value).
	33	FP	Load bus voltage (engineering units).
	34	FP	True anomaly.
	35	FP	Height.
	36	FP	Sun-earth-satellite angle.
	37-38		Zero
	39	I	Array error (raw value).
	40-45		Zero
	46-180	FP	Body attitude ($X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k$).
	181-315	FP	Paddle attitude ($X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k$).
	316-405	FP	Orbital positions (X, Y, Z), velocity (X, Y, Z).
	406-412		Zero
Data Record 1	1-704		Right ascension for 704 elements of the picture.
Data Record 2	1-704		Declination for 704 elements of the picture.
Data Record 3	1-704		Corrected intensities for 704 elements of the picture.
Data Record 4	1-704		Raw intensities for 704 elements of the picture.

Figure 4-9. Gegenschein Data Tape Format (continued)

TV TAPE FORMAT

Each file on the TV Tape consists of two records, a 120-character identification record and a 2816-word data record (Figure 4-10). The tape is low density, binary (odd parity) mode.

	Character	Contents
Identification Record (120 characters)	1-5+space	Satellite identification.
	7-8+space	Year.
	10-12+space	Station number.
	14-15+space	Analog file number.
	17-20+space	Analog tape number.
	22-23+space	Buffer file number.
	25-28+space	Buffer tape number.
	30-32+space	Date of digitalization (day of year).
	34-66+space	Identical to characters 1-33 unless errors were found in those characters, in which case this portion of the record will contain the corrected values.
	67+space	Type of data in the file: 0 = 1 kilobit realtime data 1 = 8 kilobit realtime data 2 = 64 kilobit realtime data 3 = command storage playback.
	69-77+space	Day of year, seconds of day, picture start time.
	79-90	Spare
	91-94+space	Master binary tape number.
	96-97	Master binary file number.
	98-120	Blank
Data Record (16896 characters)	1	Position of filter wheel.
	2	Data rate (1 or 8).
	3-2816	Elements of intensity per picture with the star background removed.
	(Words)	There are 704 elements; the intensity for each element is repeated four times (i.e., four values per element).

Figure 4-10. TV Tape Format

5. PROGRAM DESCRIPTIONS

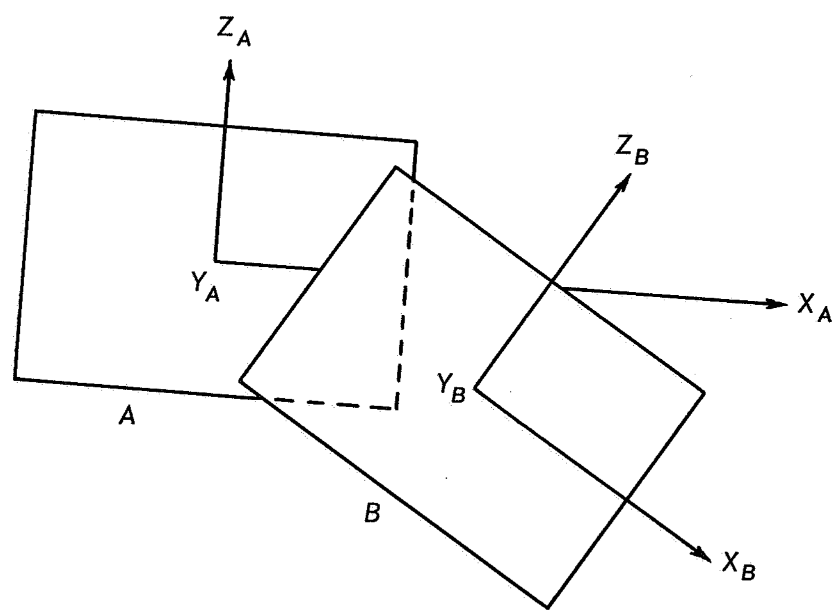
Gegenschein Processing Program

COMPUTATIONAL PROCEDURE

The data processing program associated with the gegenschein photometry experiment is used to re-create pictures taken of the sky. To attain this purpose, 11° by 16° anti-solar images of the sky are taken by an electronic camera of high photometric precision, mounted on a solar paddle of the satellite. The spherical surface subtended by the solid angle in question can be thought of as a rectangular array of elements or individual source areas having varying degrees of light intensity. The solid angle subtended by each elemental area, ΔA_{ij}, will be approximately ½° and this matrix array will consist of 22 lines ($0 \leq i \leq 21$) and 32 elements per line ($0 \leq j \leq 31$) for a total of $ij = 704$ elements.

More specifically, it is required to obtain the coordinates of surface elements on the celestial sphere and the light intensities associated with these elements. The coordinates are expressed as right ascension and declination with respect to an inertial celestial reference system and then related to the celestial inertial ecliptic framework (Figure 5-1). The associated total light intensity that is photographed is later altered by the subtraction of the light intensity due to the starry background and the preflight calibrations of the tube sensitivity.

The purpose of the mathematics involved in determining the celestial coordinates of elemental areas can be shown by means of the visual interpretation:



where rectangle A is a representation of a picture at time t, and rectangle B is the picture at $t + \Delta t$.

During the time taken in scanning a picture, not only does the picture axis rotate but translation is also involved. Thus, picture orientation is dependent upon the motion of the solar paddle and spacecraft. Although the motion is small, we are dealing with elemental areas of ½° × ½°.

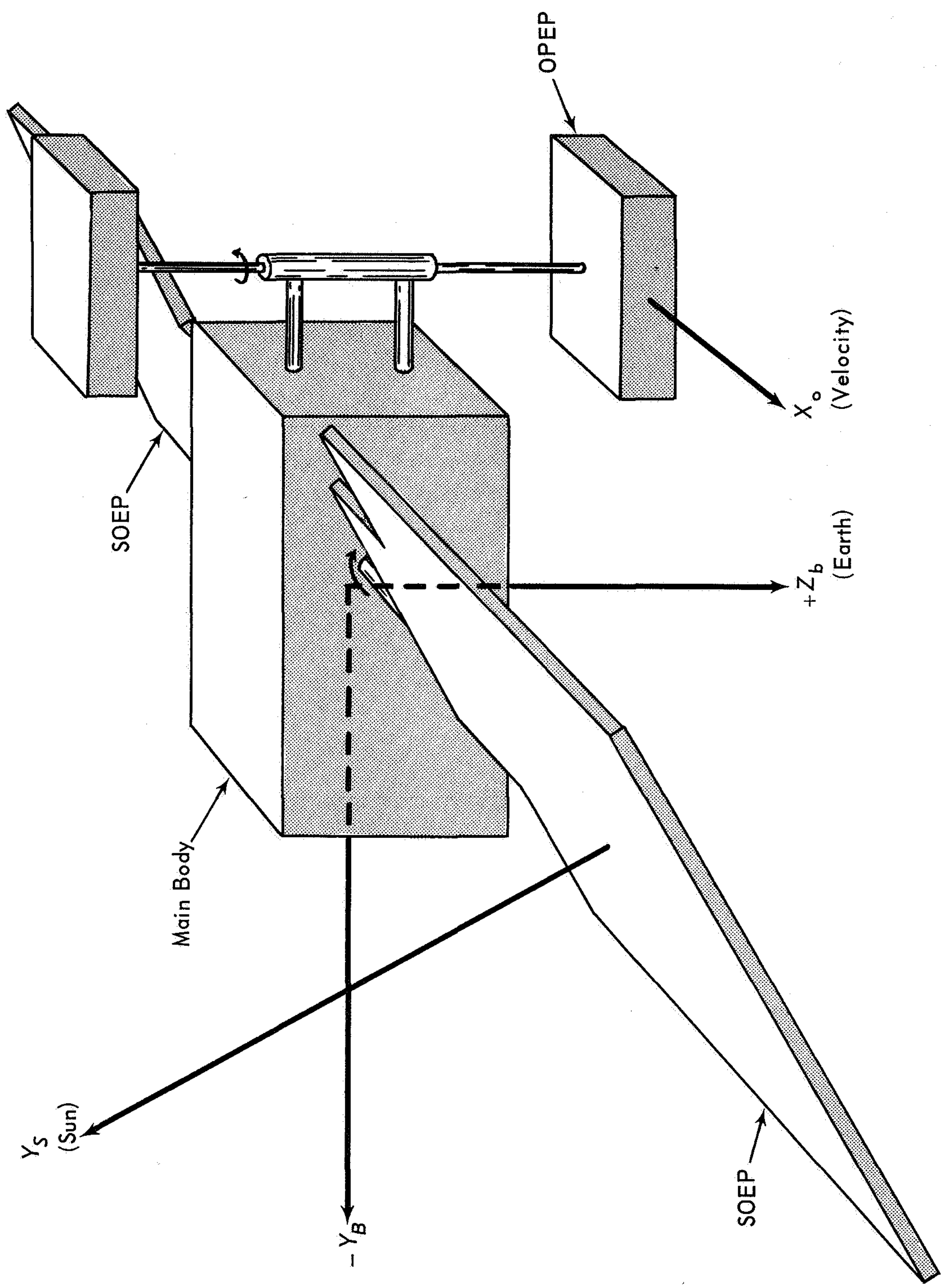


Figure 5-1

Nomenclature

(X, Y, Z)	=	celestial orthogonal axes with origin at 0, the earth's center. X and Y lie in the earth's equatorial plane with X pointing to the first point of Aries.
$(\bar{i}, \bar{j}, \bar{k})$	=	unit vectors along the X, Y, Z axes respectively.
(X_p, Y_p, Z_p)	=	right-handed orthogonal set of axes with origin, S, at the center of the satellite paddle. The X_p and Z_p axes lie in the solar face of the paddle and are coincident respectively with its longitudinal and transverse axes. The Y_p axis points in the direction of the sun.
$(\hat{X}_p, \hat{Y}_p, \hat{Z}_p)$	=	unit vectors along the X_p, Y_p, Z_p axes respectively.
(X_g, Y_g, Z_g)	=	right-handed orthogonal set of axes with origin, S, at the center of both the picture and satellite paddle. The X_g and Z_g axes lie in the anti-solar face of the paddle and are coincident respectively with the longitudinal and transverse axes of both the paddle and picture. The Y_g axis is normal to the paddle and points in the anti-solar direction.
$(\hat{X}_g, \hat{Y}_g, \hat{Z}_g)$	=	unit vectors along the X_g, Y_g, Z_g axes respectively.
(X'_g, Y'_g, Z'_g)	=	right-handed orthogonal set of axes with origin, S, at the center of the satellite paddle and Z'_g tangent to the meridian at this point and pointing in the direction of the celestial north pole. The Y'_g axis is normal to the paddle and points in the anti-solar direction.
(X, Y_1, Z_1)	=	right-handed orthogonal axes with origin at 0, the earth's center. X and Y_1 lie in the ecliptic plane with X pointing to the first point of Aries.
$(\bar{i}, \bar{j}_1, \bar{k}_1)$	=	unit vectors along the X, Y_1, Z_1 axes respectively.
α	=	right ascension in the (X, Y, Z) celestial inertial system.
δ	=	declination in the (X, Y, Z) celestial inertial system.
λ	=	right ascension in the inertial ecliptic (X, Y_1, Z_1) system.
β	=	declination in the inertial ecliptic (X, Y_1, Z_1) system.
B	=	orientation angle $Z_g S Z'_g$.
(a, b, c)	=	direction angles in the X_p, Y_p, Z_p coordinate system.
$(\bar{P}, \bar{Q}, \bar{R})$	=	projections respectively of the unit vectors $\hat{X}_g$, $\hat{Y}_g$, $\hat{Z}_g$ on the XOY celestial equatorial plane.
ΔA_{ij}	=	elemental area in the ith line and jth column of the picture.
I''_{ij}	=	observed illumination intensity associated with elemental area ΔA_{ij}.
I'_{ij}	=	intensity of illumination due to stars in the area ΔA_{ij}.
I_{ij}	=	observed illumination intensity corrected for influence of stars in the elemental area ΔA_{ij}.
$(\alpha_{ij}, \delta_{ij})$	=	right ascension and declination of the center of the area ΔA_{ij} with respect to the XYZ system.

$(\Delta \alpha'_{ij}, \Delta \delta'_{ij})$ = right ascension and declination corrections to be applied to the coordinates (α_{ij}, δ_{ij}) of the center of the picture because of improper mounting of the camera on the satellite paddle. Given by Solar Physics Branch.[1]

$(\Delta \alpha_{ij}, \Delta \delta_{ij})$ = right ascension and declination coordinates of ΔA_{ij} with respect to the center of picture. Given by Solar Physics Branch.

Determination of Celestial Coordinates of Elemental Areas

In Figure 5-2, (X, Y, Z) represent celestial orthogonal axes with their origin at 0, the earth's center. X and Y lie in the equatorial plane with X pointing to the first point of Aries. Z is perpendicular to the equatorial plane with the positive axis pointing toward the celestial north pole. Point C (X_c, Y_c, Z_c) is the geometric center of the lens of the camera mounted on the anti-solar axis of the paddle. CSY_g is the anti-solar axis of the paddle and OC is the position vector of the paddle. It is assumed that the camera axis is coincident with the paddle axis. In section 4, a method for correcting small differences which may exist between the two axes is described.

The celestial spherical surface *abdc* is the surface subtended by the 11° by 16° solid camera angle at C. The Z_g and X_g axes are coincident with the transverse and longitudinal axes of the picture. The right ascensions and declinations of OX_g, OY_g, OZ_g are given by αX_g, αY_g, αZ_g and δX_g, δY_g, δZ_g respectively.

The angle $B = Z'_g S Z_g$ is the orientation angle of the picture and is seen to be the angle between the transverse Z_g axis of the picture and the tangent to the meridian, Z_g, at the center of the picture.

The steps involved in the computation of the celestial right ascension and declination of an elemental picture area, ΔA_{ij}, are the following:

(a) <u>Right Ascension and Declination of</u> X_g, Y_g, Z_g <u>Axes</u>

From the Attitude-Orbit program, the functional relationship of unit vectors ($\hat{X}_p$, $\hat{Y}_p$, $\hat{Z}_p$) along the X_p, Y_p, Z_p paddle axes in terms of unit vectors ($\bar{i}$, $\bar{j}$, $\bar{k}$) along the X, Y, Z axes of the equatorial system are made available to us. Conveniently, the relationship of the G to P system is the following: $\hat{X}_g = -\hat{X}_p$, $\hat{Y}_g = -\hat{Y}_p$, and $\hat{Z}_g = \hat{Z}_p$

Since

$$\hat{\xi} = \cos a\xi\bar{i} + \cos b\xi\bar{j} + \cos c\xi\bar{k} \qquad (\xi = X_p, Y_p, Z_p)$$

$$\hat{X}_g = -\cos aX_p\bar{i} - \cos bX_p\bar{j} - \cos cX_p\bar{k} = \bar{P} - \cos cX_p\bar{k} \tag{1A}$$

$$\hat{Y}_g = -\cos aY_p\bar{i} - \cos bY_p\bar{j} - \cos cY_p\bar{k} = \bar{Q} - \cos cY_p\bar{k} \tag{1B}$$

$$\hat{Z}_g = \cos aZ_p\bar{i} + \cos bZ_p\bar{j} + \cos cZ_p\bar{k} = \bar{R} + \cos cZ_p\bar{k} \tag{1C}$$

$$\cos \alpha X_g = \bar{P}\cdot\bar{i}/|\bar{P}| = -\cos aX_p/(\cos^2 aX_p + \cos^2 bX_p)^{1/2} \tag{1}$$

$$\cos \alpha Y_g = \bar{Q}\cdot\bar{i}/|\bar{Q}| = -\cos aY_p/(\cos^2 aY_p + \cos^2 bY_p)^{1/2} \tag{2}$$

$$\cos \alpha Z_g = \bar{R}\cdot\bar{i}/|\bar{R}| = \cos aZ_p/(\cos^2 aZ_p + \cos^2 bZ_p)^{1/2} \tag{3}$$

[1]Dr. Charles Wolff, Solar Physics Branch, Code 614; GSFC, Greenbelt, Maryland 20771.

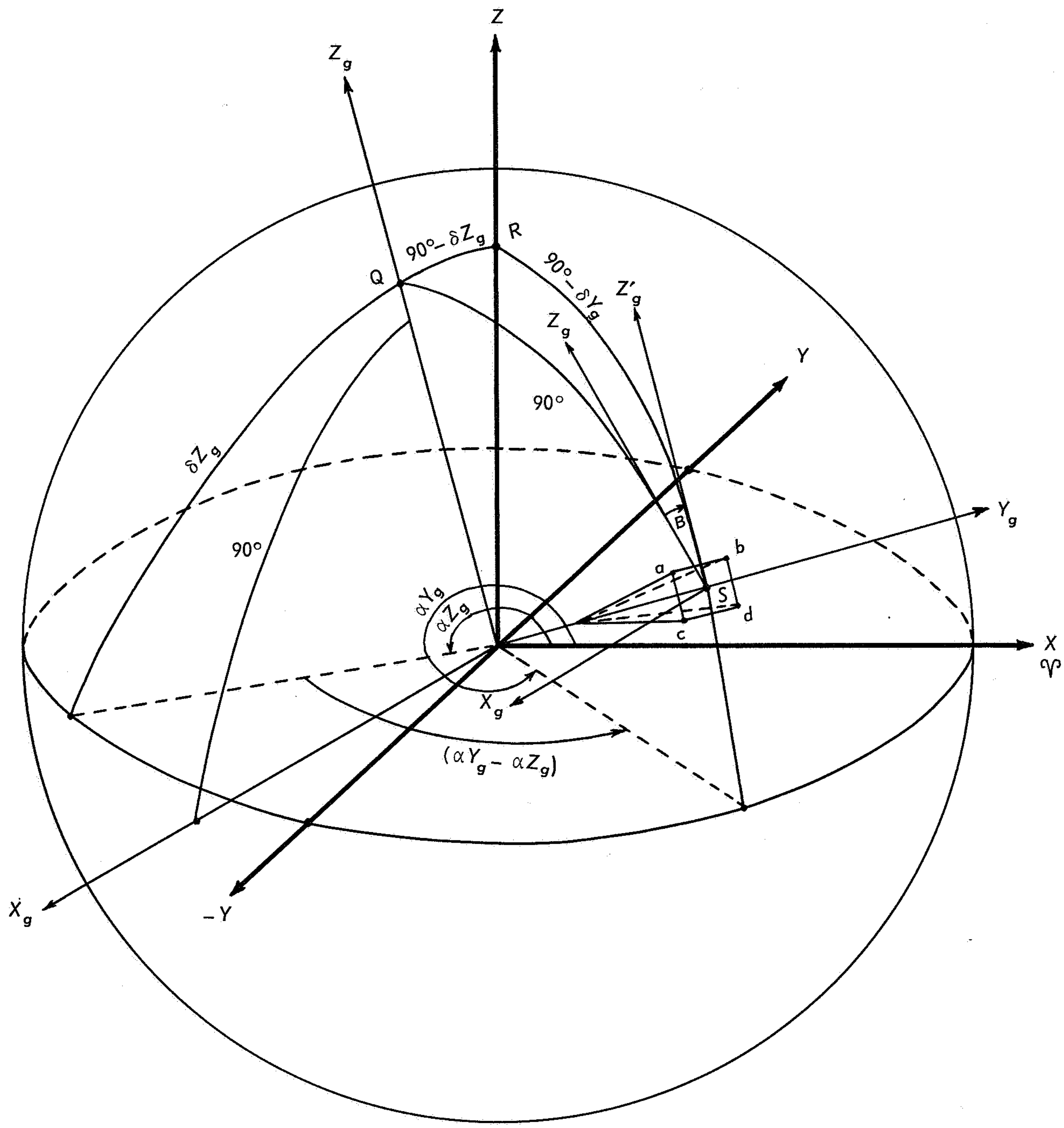


Figure 5-2—Cèlestial Coordinate System

$$\sin \delta X_g = \hat{X}_g \cdot \bar{k} = -\cos c X_p \tag{4}$$

$$\sin \delta Y_g = \hat{Y}_g \cdot \bar{k} = -\cos c Y_p \tag{5}$$

$$\sin \delta Z_g = \hat{Z}_g \cdot \bar{k} = \cos c Z_p \tag{6}$$

$$\hat{X}_g = -X'\bar{i} - Y'\bar{j} - Z'\bar{k}$$

$$\hat{Y}_g = -X''\bar{i} - Y''\bar{j} - Z''\bar{k}$$

$$\hat{Z}_g = X'''\bar{i} + Y'''\bar{j} + Z'''\bar{k}$$

$$[(X')^2 + (Y')^2 + (Z')^2]^{1/2} = 1 \tag{7}$$

where:

$$X' = \cos a X_p$$

$$Y' = \cos b X_p \tag{8}$$

$$Z' = \cos c X_p$$

$$X'' = \cos a Y_p \tag{9}$$

etc.

(b) Smoothing Program

In the computations associated with the objective stated above, the right ascension and declination of the X_g and Y_g axes are required as continuous functions of time. As can be seen from an inspection of equations (2), (3), (5), and (6), this involves the smoothing of the six components of equations (1B) and (1C).

During a picture sequence, each of the six variables have up to 15 values depending upon the satellite data rate. These data points are smoothed to a quadratic approximating function in time using a least squares technique.

(c) Determination of Orientation Angle B

In the spherical triangle QRS of Figure 5-2, the angle between tangents to the great circle arcs $(90° - \delta Z_g)$ and $(90° - \delta Y_g)$ at the point R has the magnitude $(\alpha Y_g - \alpha Z_g)$. The angle B is the included angle between SZ'_g and SZ_g. At the point S, SZ_g is tangent to the 90° great circle arc between Z_g and Y_g axes and SZ'_g is tangent to the $(90° - \delta Y_g)$ great circle arc. Angles $ZOZ_g = (90° - \delta Z_g)$ and $Y_g OZ_g = 90°$; therefore:

$$\begin{aligned}\sin B &= \sin (90° - \delta Z_g) \sin (\alpha Y_g - \alpha Z_g) / \sin 90° \\ &= \cos \delta Z_g \sin (\alpha Y_g - \alpha Z_g) \\ &= \cos \delta Z_g [\sin \alpha Y_g \cos \alpha Z_g - \cos \alpha Y_g \sin \alpha Z_g]\end{aligned} \tag{10}$$

(d) Determination of Celestial Right Ascension and Declination

At this point, we have the right ascension and declination of the Y_g and Z_g axes as continuous functions of time. Since the angle B is a function of these variables, it can be evaluated at any time instant.

As the satellite orbits, the instantaneous position of the center of the picture can be determined by evaluating $Y_g = f(t)$ and $\delta Y_g = h(t)$ at the moment t_{ij} corresponding to the event ΔA_{ij}. In this connection, it is assumed that the camera axis is mounted coincidentally with the paddle axis OY_g. In the event this condition does not prevail, corrections ($\Delta \alpha'_{ij}$, $\Delta \delta'_{ij}$) will be added in the determination of α_{ij}, δ_{ij} of the area ΔA_{ij}. The development follows:

$$X_g' = X_g \cos B - Z_g \sin B \tag{11}$$

$$Z_g' = Z_g \sin B - Z_g \cos B \tag{12}$$

Figure 5-3 is a representation of conditions in the tangent plane at S at $t = t_{ij}$. The coordinates X_g, Z_g are furnished by the Solar Physics Branch for each element of the picture.

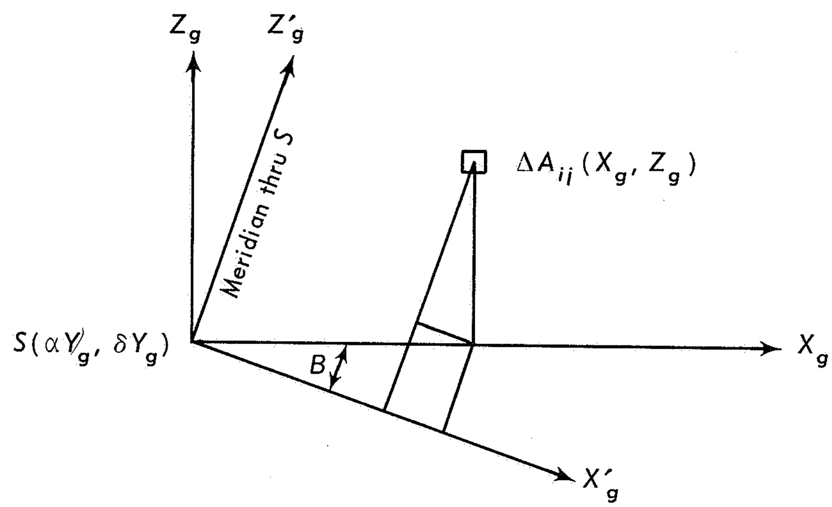


Figure 5-3—Tangent Plane

On the basis of the foregoing and in view of Figure 5-4, the right ascension and declination of ΔA_{ij}; are:

$$\begin{aligned} \alpha_{ij} &= \alpha Y_g + \Delta \alpha_{ij} + \Delta \alpha'_{ij} \\ \delta_{ij} &= \delta Y_g + \Delta \delta_{ij} + \Delta \delta'_{ij} \end{aligned} \tag{13}$$

where $\Delta \alpha_{ij}$ and $\Delta \delta_{ij}$ have the following definitions:

$$\Delta \delta_{ij} = Z'_g \tag{14}$$

$$X'_g = \cos [(\delta Y_g + \Delta \delta'_{ij}) + \Delta \delta_{ij}] \cdot \Delta \alpha_{ij} \tag{15}$$

$$\Delta \alpha_{ij} = \frac{X'_g}{\cos [(\delta Y_g + \Delta \delta'_{ij}) + \Delta \delta_{ij}]} \tag{16}$$

$$\Delta \alpha_{ij} = \frac{X'_g}{\cos [(\delta Y_g + \Delta \delta'_{ij}) + Z'_g]} \tag{17}$$

and $\Delta \alpha'_{ij} + \Delta \delta'_{ij}$ are corrections based upon the mounting of the camera on the solar paddle.

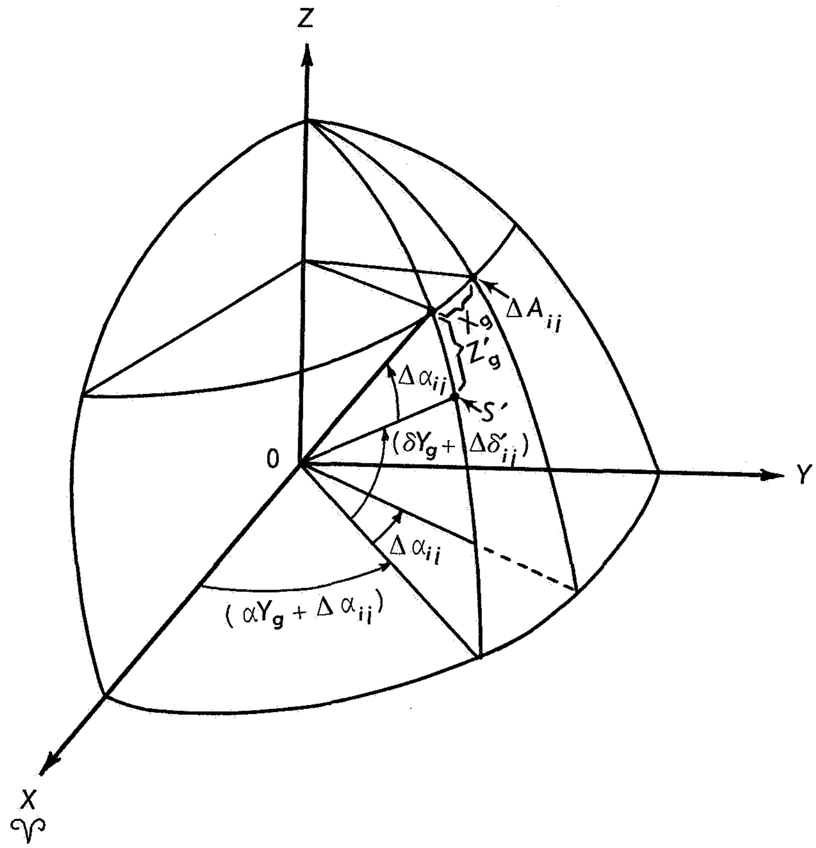


Figure 5-4—Relationship of Individual Picture Elements to Celestial Coordinate System

Corrections Caused by Starry Background

Each picture of the sky can be considered to be a matrix array of i lines and j columns of elemental areas, ΔA_{ij}. As stated previously in section 1 above, associated with the center of each ΔA_{ij}, there is a couplet $(\alpha_{ij}, \delta_{ij})$, associated with the time of the event $t = t_{ij}$.

The observed illumination intensities I''_{ij}, associated with the elemental areas ΔA_{ij}, are obtained from the picture. The α and δ bounds of the square element at area, ΔA_{ij}, having an area of $4R^2$, are given by $(\alpha_{ij} \pm R)$ and $(\delta_{ij} \pm R)$. Due to the limited resolving power of the camera, it is believed that, in reality, each ΔA_{ij} can be considered a circle having a radius R of approximately 0.35°.

The influence of the illumination of the stars, I'_{ij}, can be eliminated by using the equation $I_{ij} = I''_{ij} - I'_{ij}$. To accomplish this correction, the following steps are important:

(1) The intensities of all stars, I'_{ij}, with their corresponding α_{ij} and δ_{ij} values to the nearest .01°, are stored in computer memory.

(2) The ij observed illumination intensities I''_{ij} with their relevant α_{ij} and δ_{ij} values to the nearest .01° are stored in memory for each picture.

(3) For each element of (2), the star table is searched to see if any star lies within ($\alpha_{ij} \pm R$, $\delta_{ij} \pm R$). If so, star intensity I'_{ij} is subtracted.

Conversion of Celestial Equatorial Coordinates to Ecliptic Longitude and Latitude

Before print out, the celestial equatorial right ascension and declination coordinates (α_{ij}, δ_{ij}) of ΔA_{ij} are converted to ecliptic longitude and latitude (λ_{ij}, β_{ij}). The conversion relationships appear at the end of this section.

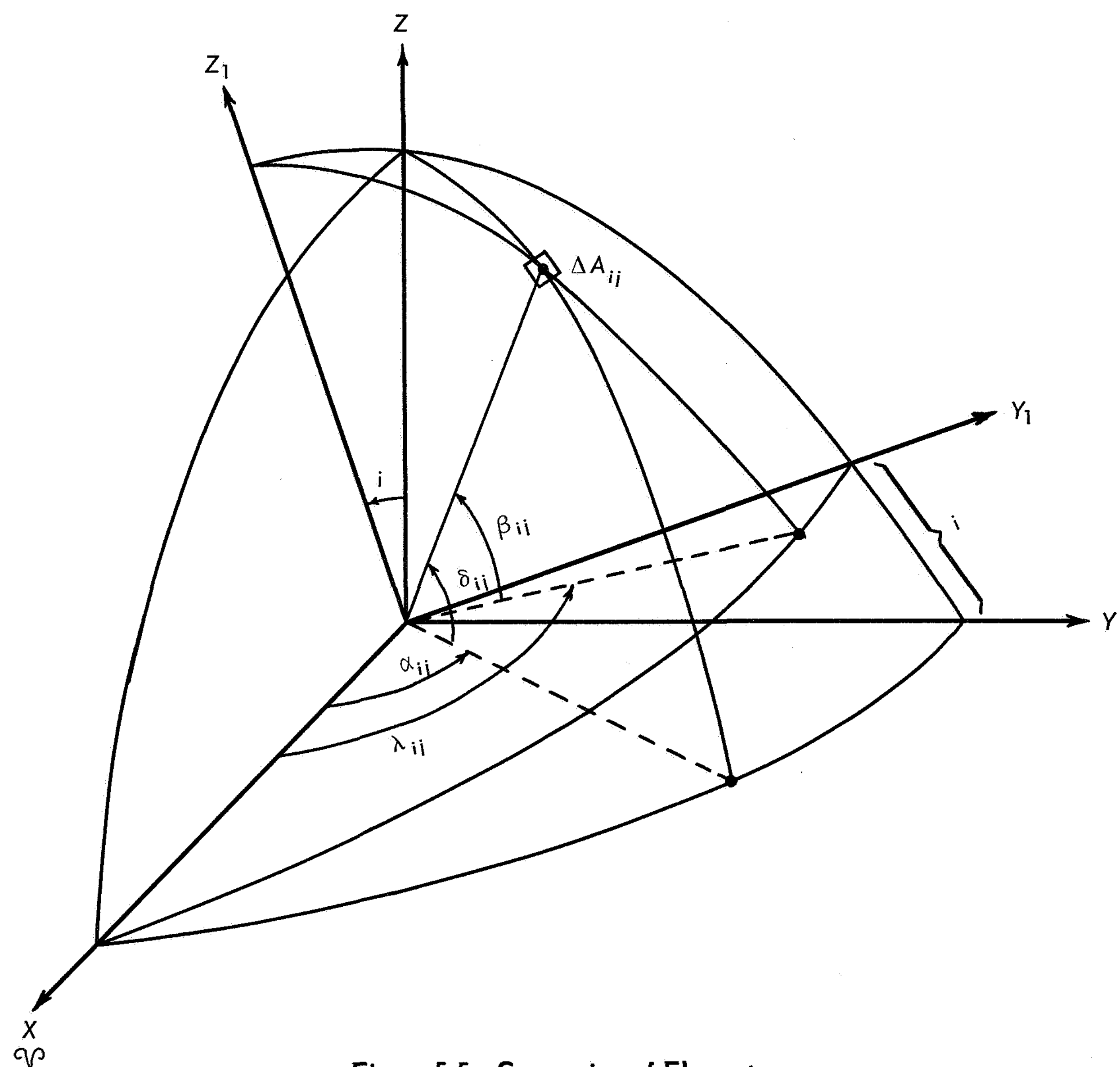


Figure 5-5—Conversion of Elements

In Figure 5-5, XOY is the celestial equatorial plane and Z_1OY_1 is the ecliptic plane oriented at an inclination angle i of approximately 23.5°. The coordinates α_{ij} and δ_{ij} of ΔA_{ij} are given. It is required to find λ_{ij} and β_{ij}.

If rectangular coordinates are used, it will be observed that only the Y and Z coordinates change. The X axis is common to both systems. If the point P(Y, Z) is the projection of the center of ΔA_{ij} on the YOZ plane, we have the condition shown in Figure 5-6.

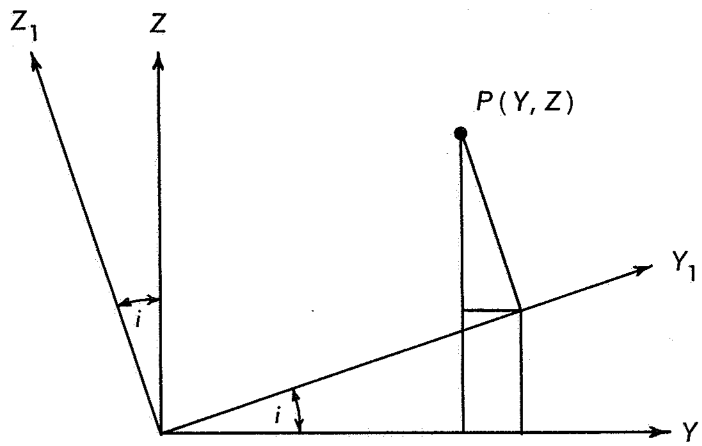


Figure 5-6—Rectangular Coordinates

$$
\begin{aligned}
Y &= Y_1 \cos i - Z_1 \sin i & \qquad \bar{j} &= \bar{j}_1 \cos i - \bar{k}_1 \sin i \\
Z &= Y_1 \sin i + Z_1 \cos i & \qquad \bar{k} &= \bar{j}_1 \sin i + \bar{k}_1 \cos i
\end{aligned}
\tag{18}
$$

Let $\bar{r}$ be a unit vector along the line connecting the origin of Figure 5-5 with the center of ΔA_{ij}; then:

$$\bar{r} = X_{ij}\bar{i} + Y_{ij}\bar{j} + Z_{ij}\bar{k} \tag{19}$$

$$\bar{r}\cdot\bar{r} = X_{ij}^2 + Y_{ij}^2 + Z_{ij}^2 = 1 \tag{20}$$

In equation 20, X_{ij}, Y_{ij}, Z_{ij} can be thought of as the directional cosines with respect to the XYZ system of the line joining the origin of Figure 5-5 with the point $(\alpha_{ij}, \delta_{ij})$; consequently,

$$\sin \delta_{ij} = \bar{r}\cdot\bar{k} = Z_{ij} \tag{21}$$

In equation 21, Z_{ij} can be evaluated since δ_{ij} is known. An asterisk in the following will be an indication of known quantities.

$$\cos \alpha_{ij}^* = (X_{ij}\bar{i} + Y_{ij}\bar{j})\cdot i = X_{ij}/(X_{ij}^2 + Y_{ij}^2)^{1/2} \tag{22}$$

$$X_{ij}^{2} = (X_{ij}^{2} + Y_{ij}^{2})(\cos \alpha_{ij}^{*}) \tag{23}$$

From (20):

$$(X_{ij}^{2} + Y_{ij}^{2}) = 1 - (Z_{ij}^{*})^{2} \tag{24}$$

Therefore:

$$X_{ij} = \pm \sqrt{[1 - (Z_{ij}^{*})^{2}](\cos^{2} \alpha_{ij}^{*})} \tag{25}$$

Y_{ij} can be evaluated from equation (20) since both X_{ij} and Y_{ij} have now been determined.

Using equations (18) and (19), $\bar{r}$ can be expressed with respect to unit vectors along the axes of the ecliptic $(XY_1 Z_1)$ system.

$$\bar{r} = X_{ij}\bar{i} + Y_{ij}(\cos i\,\bar{j}_1 - \sin i\,\bar{k}_1) + Z_{ij}(\sin i\,\bar{j}_1 + \cos i\,\bar{k}_1) \tag{26}$$

$$\bar{r} = X_{ij}\bar{i} + (Y_{ij}\cos i + Z_{ij}\sin i)\bar{j}_1 + (Z_{ij}\cos i - Y_{ij}\sin i)\bar{k}_1 \tag{27}$$

$$\sin \beta_{ij} = \bar{r} \cdot \bar{k}_1 = Z_{ij}\cos i - Y_{ij}\sin i \tag{28}$$

$$\cos \lambda_{ij} = \frac{[X_{ij}\bar{i}\ (Y_{ij}\cos i + Z_{ij}\sin i)\bar{j}_1] \cdot \bar{i}}{[X_{ij}^{2} + (Y_{ij}\cos i + Z_{ij}\sin i)^{2}]^{1/2}} \tag{29}$$

$$\cos \lambda_{ij} = \frac{X_{ij}}{[X_{ij}^{2} + (Y_{ij}\sin i + Z_{ij}\sin i)^{2}]^{1/2}} \tag{30}$$

On a unit sphere:

$$X_{ij} = \cos \delta_{ij} \cos \alpha_{ij} \tag{31}$$

$$Y_{ij} = \cos \delta_{ij} \sin \alpha_{ij} \tag{32}$$

$$Z_{ij} = \sin \delta_{ij}$$

Therefore:

$$\sin \beta_{ij} = \sin \delta_{ij} \cos i - \cos \delta_{ij} \sin \alpha_{ij} \sin i \tag{33}$$

$$\cos \lambda_{ij} = \frac{\cos \delta_{ij} \cos \alpha_{ij}}{[\cos^{2} \delta_{ij} \cos^{2} \alpha_{ij} + (\cos \delta_{ij} \sin \alpha_{ij} \sin i + \sin \delta_{ij} \sin i)^{2}]^{1/2}} \tag{34}$$

Least Squares Technique

When the time dependent variable $X = X(T)$ is given and a quadratic fit is required such that $X = A + BT + CT^{2}$, the applicable least squares normal equations and their solutions for the determination of the coefficients in terms of n sets of (T_i, X_i) values are:

$$\sum_{i=1}^{n} x_i = na + b\sum_{i=1}^{n} t_i + c\sum_{i=1}^{n} t^{2} \qquad \text{where } n \geq 5 \tag{1}$$

$$\sum_{i=1}^{n} x_i t_i = a \sum_{i=1}^{n} t_i + b \sum_{i=1}^{n} t_i^2 + c \sum_{i=1}^{n} t_i^3 \qquad (2)$$

$$\sum_{i=1}^{n} x_i t_i^2 = a \sum_{i=1}^{n} t_i^2 + b \sum_{i=1}^{n} t_i^3 + c \sum_{i=1}^{n} t_i^4 \qquad (3)$$

$$\sum_{i=1}^{n} x_i = V_0 \qquad \sum_{i=1}^{n} x_i t_i = V_1 \qquad \sum_{i=1}^{n} x_i t_i^2 = V_2$$

$$n = S_0 \qquad \sum_{i=1}^{n} t_i = S_1 \qquad \sum_{i=1}^{n} t_i^2 = S_2 \qquad \sum_{i=1}^{n} t_i^3 = S_3 \qquad \sum_{i=1}^{n} t_i^4 = S_4$$

$$a + \beta_{12}\, b + \beta_{13}\, c = \beta_{14} \qquad (4)$$

$$\beta_{22}\, b + \beta_{23}\, c = \beta_{24} \qquad (5)$$

$$\beta_{32}\, b + \beta_{33}\, c = \beta_{34} \qquad (6)$$

where:

$$\beta_{12} = S_1 / S_0 \qquad \beta_{13} = S_2 / S_0 \qquad \beta_{14} = V_0 / S_0$$

$$\beta_{22} = S_2 - \beta_{12} S_1 \qquad \beta_{23} = S_3 - \beta_{13} S_1 \qquad \beta_{24} = V_1 - \beta_{14} S_1$$

$$\beta_{32} = S_3 - \beta_{12} S_2 \qquad \beta_{33} = S_4 - \beta_{13} S_2 \qquad \beta_{34} = V_2 - \beta_{14} S_2$$

$$b + K_{23}\, c = K_{24} \qquad (7)$$

$$K_{33}\, c = K_{34} \qquad (8)$$

where:

$$K_{23} = \beta_{23} / \beta_{22} \qquad K_{24} = \beta_{24} / \beta_{22}$$

$$K_{33} = \beta_{33} - K_{23}\, \beta_{32} \qquad K_{34} = \beta_{34} - K_{24}\, \beta_{32}$$

From (8): $$c = K_{34} / K_{33} \qquad (9)$$

From (7): $$b = K_{24} - (K_{23})\, c \qquad (10)$$

From (4): $$a = \beta_{14} - (\beta_{12})\, b - (\beta_{13})\, c \qquad (11)$$

Name	Code	Description
EGO20	Sleuth II	Main Program - Experiment #20
RD	Sleuth II	Reads BOSS and Circular Arc Data.
TESTD	Sleuth II	Searches DECOM tape for starting point of good data.
FNDTIM	Sleuth II	Computes picture start and end time.
CKROUT	Sleuth II	Data handling and checking routine.
TVTAPE	Sleuth II	Writes TV output tape.
STARRY	Sleuth II	Subtracts Starry Background intensities.
DECID	Sleuth II	Reads DECOM ID from tape.
DECDAT	Sleuth II	Reads DECOM data from tape.
ASPID	Sleuth II	Reads Attitude ID from tape.
ASPDAT	Sleuth II	Reads Attitude data from tape.
LSQS	Fortran IV	Least Squares Quadratic Solution and computation of attitude elements.
ROTATE	Fortran IV	Rotates RA and DEC for every picture element into ecliptic coordinates.
OUTPUT	Fortran IV	Writes output on HSP and tape.

EXEC II Library

EBCDB$	KTYPE$	TEF$
MERR$	PRINT$	TRF$
MEXIT$		TRI$
MVFY1$		TPE$
MVFY2$		TPB$
		TSWAP$
		TWR$

EGO20 (Sleuth II)

Function

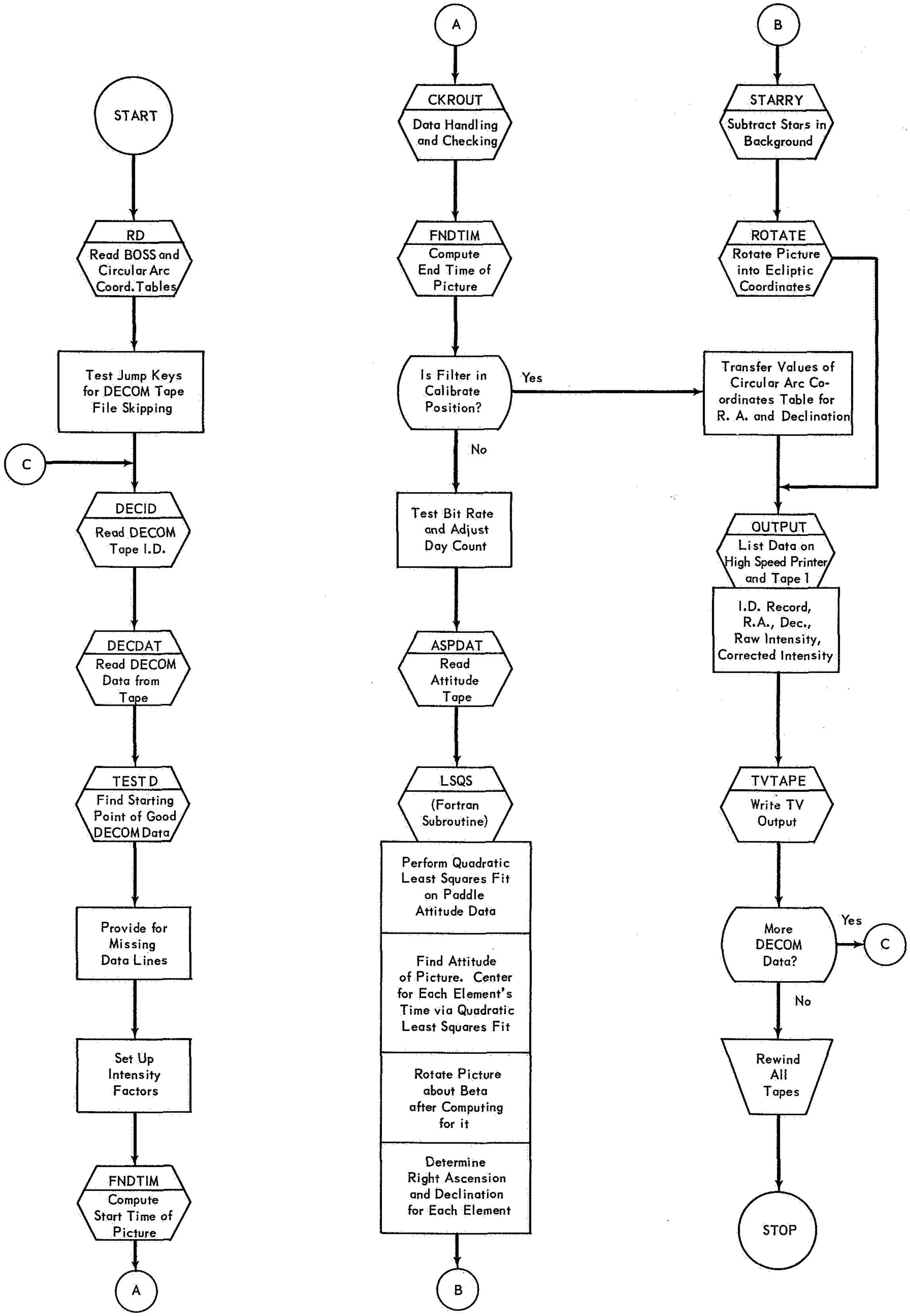
This is the main routine for the Gegenschein Processing Program. It calls the major READ, COMPUTE and WRITE routines, handles major loop control, and handles finalization.

Calling Sequence

None

Operational Description

1. Reads BOSS and Circular Arc Coordinates tables.
2. Skip Decom input files under jump key control.
3. Reads Decom tape.
4. Locates starting point of "good" Decom data.
5. Edits data and provides missing data items.
6. Accomodates filter wheel position and bit rate.
7. Reads Attitude (aspect) tape.
8. Performs quadratic least squares fit on paddle and attitude data.
9. Rotates picture and determines RA and DEC for each of the 704 picture elements.
10. Subtracts starry background.
11. Rotates picture into ecliptic coordinates.
12. Outputs data to high speed printer and tape.
13. Writes TV tape output.
14. Loops back if more Decom data.
15. Finalization when no more Decom data.


START
RD
Read BOSS and Circular Arc Coord. Tables
Test Jump Keys for DECOM Tape File Skipping
C
DECID
Read DECOM Tape I.D.
DECDAT
Read DECOM Data from Tape
TEST D
Find Starting Point of Good DECOM Data
Provide for Missing Data Lines
Set Up Intensity Factors
FNDTIM
Compute Start Time of Picture
A
A
CKROUT
Data Handling and Checking
FNDTIM
Compute End Time of Picture
Is Filter in Calibrate Position?
Yes
No
Test Bit Rate and Adjust Day Count
ASPDAT
Read Attitude Tape
LSQS
(Fortran Subroutine)
Perform Quadratic Least Squares Fit on Paddle Attitude Data
Find Attitude of Picture. Center for Each Element's Time via Quadratic Least Squares Fit
Rotate Picture about Beta after Computing for it
Determine Right Ascension and Declination for Each Element
B
B
STARRY
Subtract Stars in Background
ROTATE
Rotate Picture into Ecliptic Coordinates
Transfer Values of Circular Arc Co-ordinates Table for R. A. and Declination
OUTPUT
List Data on High Speed Printer and Tape 1
I.D. Record, R.A., Dec., Raw Intensity, Corrected Intensity
TVTAPE
Write TV Output
More DECOM Data?
Yes
C
No
Rewind All Tapes
STOP

RD (Sleuth II)

Function

Reads BOSS and circular arc table data.

Calling Sequence

In-line code

Operational Description

1. Read BOSS table records into core (6 words/record).

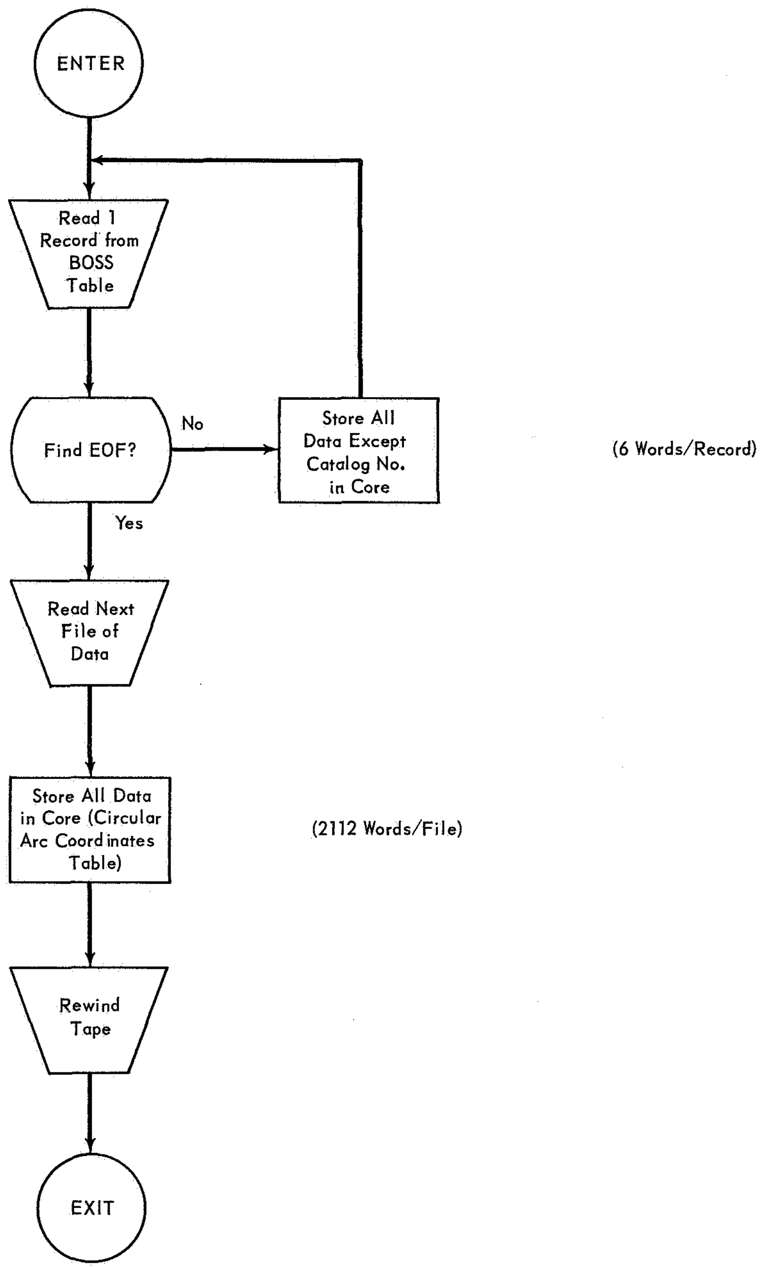
2. Read Circular Arc Coordinates table into core (2112 words/file).

3. Rewind tape I.

4. Continue.

Programs Used

MVFY1$
MVFY2$
TRF$
TRI$


ENTER
Read 1 Record from BOSS Table
Find EOF?
No
Store All Data Except Catalog No. in Core
(6 Words/Record)
Yes
Read Next File of Data
Store All Data in Core (Circular Arc Coordinates Table)
(2112 Words/File)
Rewind Tape
EXIT

TESTD (Sleuth II)

Function

Searches DECOM tape for starting point of good data.

Calling Sequence

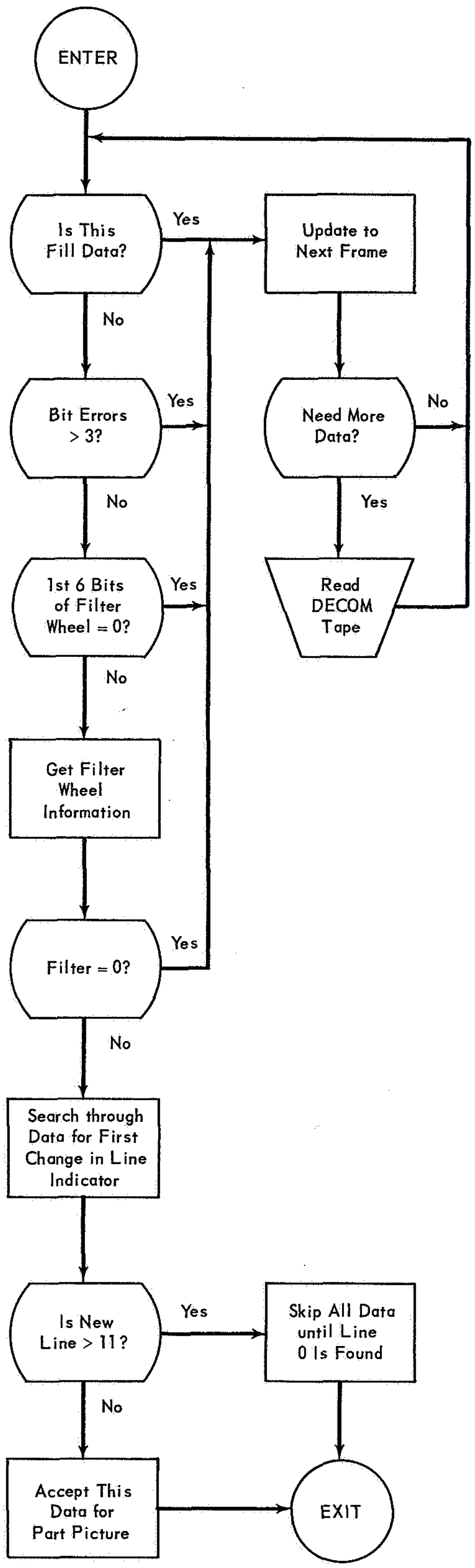
In-line code.

Operational Description

1. Test for fill data.
2. Test for bit errors.
3. Test filter wheel position.
4. Search for change in line indicator.
5. If line indicator is higher than 11, skip data until line zero is found.
6. Accept data for part picture.
7. Continue.

Programs Used

DECDAT
ASPID


ENTER
Is This Fill Data?
Yes
No
Update to Next Frame
Bit Errors > 3?
Yes
No
Need More Data?
No
Yes
1st 6 Bits of Filter Wheel = 0?
Yes
No
Read DECOM Tape
Get Filter Wheel Information
Filter = 0?
Yes
No
Search through Data for First Change in Line Indicator
Is New Line > 11?
Yes
No
Skip All Data until Line 0 Is Found
Accept This Data for Part Picture
EXIT

FNDTIM (Sleuth II)

Function

Computes picture start or end time.

Calling Sequence

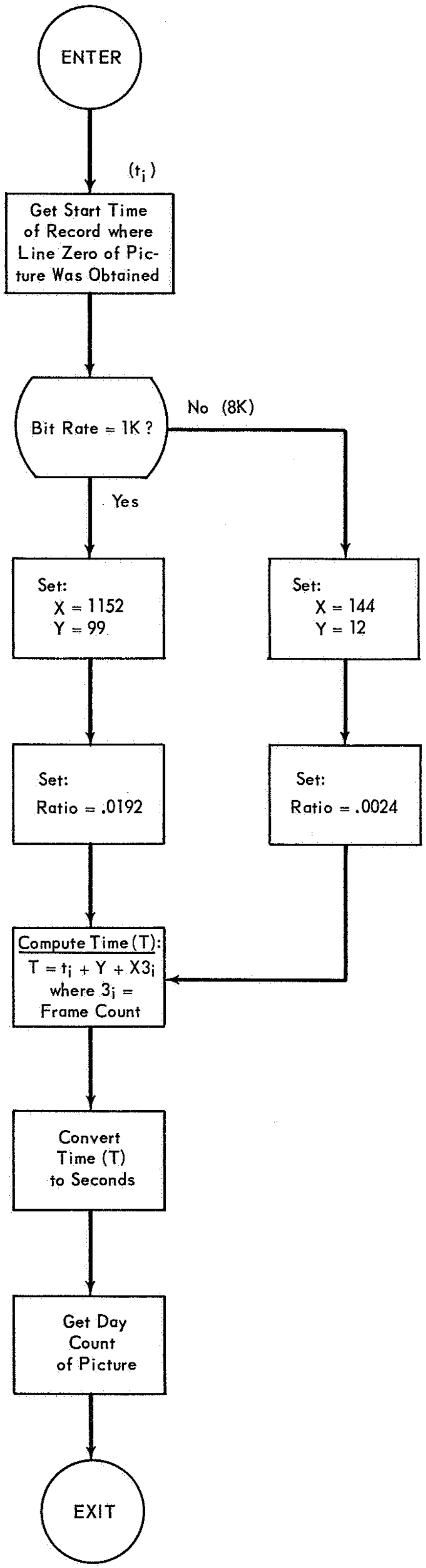
SLJ FNDTIM

Operational Description

1. Pick up start time of line zero.
2. Test kilobit rate and set x, y and RATIO.
3. Compute TIME and convert to seconds.
4. Get day count of picture.
5. Exit.

Programs Used

None


ENTER
(t_i)
Get Start Time of Record where Line Zero of Picture Was Obtained
Bit Rate = 1K ?
No (8K)
Yes
Set: X = 1152 Y = 99
Set: X = 144 Y = 12
Set: Ratio = .0192
Set: Ratio = .0024
Compute Time (T): $T = t_i + Y + X3_i$ where 3_i = Frame Count
Convert Time (T) to Seconds
Get Day Count of Picture
EXIT

CKROUT (Sleuth II)

Function

Data Handling and Checking Routine

Calling Sequence

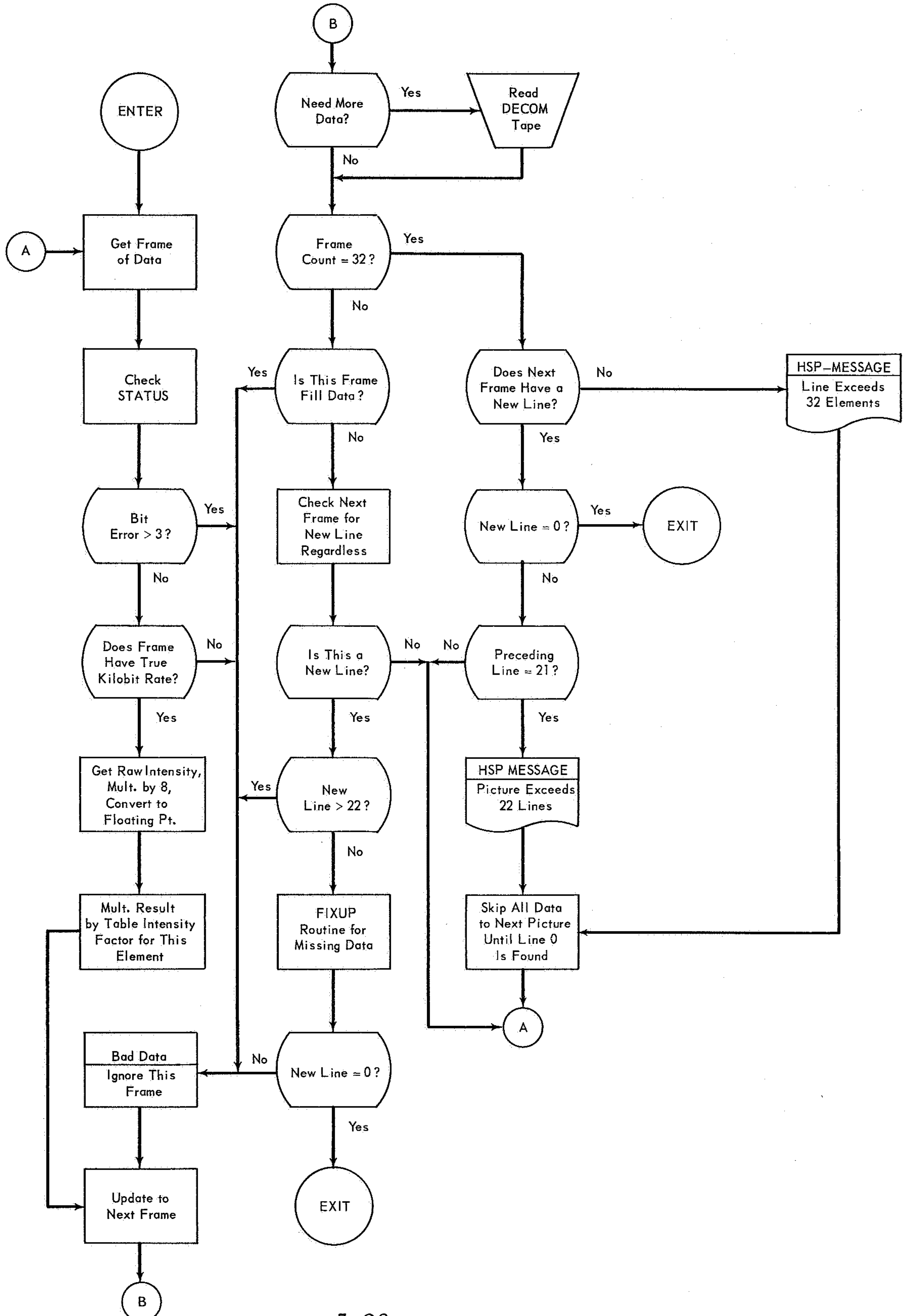
In-line code

Operational Description

1. Pick up data frame.
2. Check status.
3. Test for bit errors.
4. Test kilobit rate.
5. Multiply by factor of 8 and convert raw intensity to floating point.
6. Apply intensity factor from table for this element.
7. Read more data from DECOM tape when needed.
8. Print message and skip to next frame when frame count exceeds 32 elements.
9. Test for fill data.
10. Fix up routine for missing data (new line > 22).
11. Print message and skip to next frame when picture exceeds 22 lines.
12. Continue when new line number equals zero.

Programs Used

DECDAT
PRINT$
RESET
TESTD (entry SKPICT)


ENTER
A
Get Frame of Data
Check STATUS
Bit Error > 3 ?
Yes
No
Does Frame Have True Kilobit Rate?
No
Yes
Get Raw Intensity, Mult. by 8, Convert to Floating Pt.
Mult. Result by Table Intensity Factor for This Element
Bad Data Ignore This Frame
Update to Next Frame
B
B
Need More Data?
Yes
Read DECOM Tape
No
Frame Count = 32 ?
Yes
No
Is This Frame Fill Data ?
Yes
No
Check Next Frame for New Line Regardless
Is This a New Line?
No
Yes
New Line > 22 ?
Yes
No
FIXUP Routine for Missing Data
New Line = 0 ?
No
Yes
EXIT
Does Next Frame Have a New Line?
No
Yes
HSP–MESSAGE
Line Exceeds 32 Elements
New Line = 0 ?
Yes
No
EXIT
Preceding Line = 21 ?
No
Yes
HSP MESSAGE
Picture Exceeds 22 Lines
Skip All Data to Next Picture Until Line 0 Is Found
A

TVTAPE (Sleuth II)

Function

Writes TV output tape.

Calling Sequence

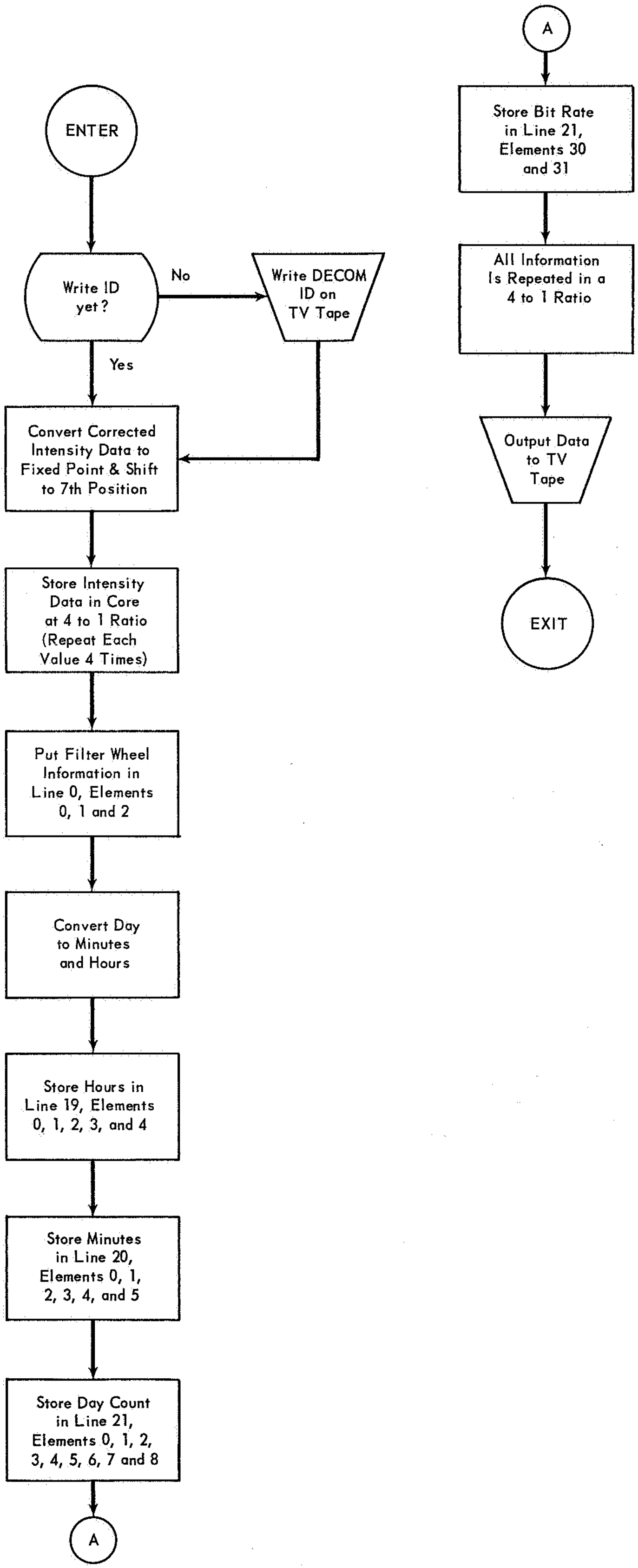
In-line code.

Operational Description

1. Write DECOM identification on TV tape if it has not yet been done.
2. Convert and shift intensity data and store at 4 to 1 ratio.
3. Pick up, convert as necessary and store in proper line/element array:
   a. Filter wheel information.
   b. Hours, minutes, day count.
   c. Bit rate.
4. Repeat all information at 4 to 1 ratio.
5. Write output data on TV tape.
6. Continue.

Programs Used

MVFY1$
MVFY2$
TWR$
KTYPE$
MERR$


ENTER
Write ID yet?
No
Write DECOM ID on TV Tape
Yes
Convert Corrected Intensity Data to Fixed Point & Shift to 7th Position
Store Intensity Data in Core at 4 to 1 Ratio (Repeat Each Value 4 Times)
Put Filter Wheel Information in Line 0, Elements 0, 1 and 2
Convert Day to Minutes and Hours
Store Hours in Line 19, Elements 0, 1, 2, 3, and 4
Store Minutes in Line 20, Elements 0, 1, 2, 3, 4, and 5
Store Day Count in Line 21, Elements 0, 1, 2, 3, 4, 5, 6, 7 and 8
A
A
Store Bit Rate in Line 21, Elements 30 and 31
All Information Is Repeated in a 4 to 1 Ratio
Output Data to TV Tape
EXIT

STARRY (Sleuth II)

Function

Subtracts starry background intensities.

Calling Sequence

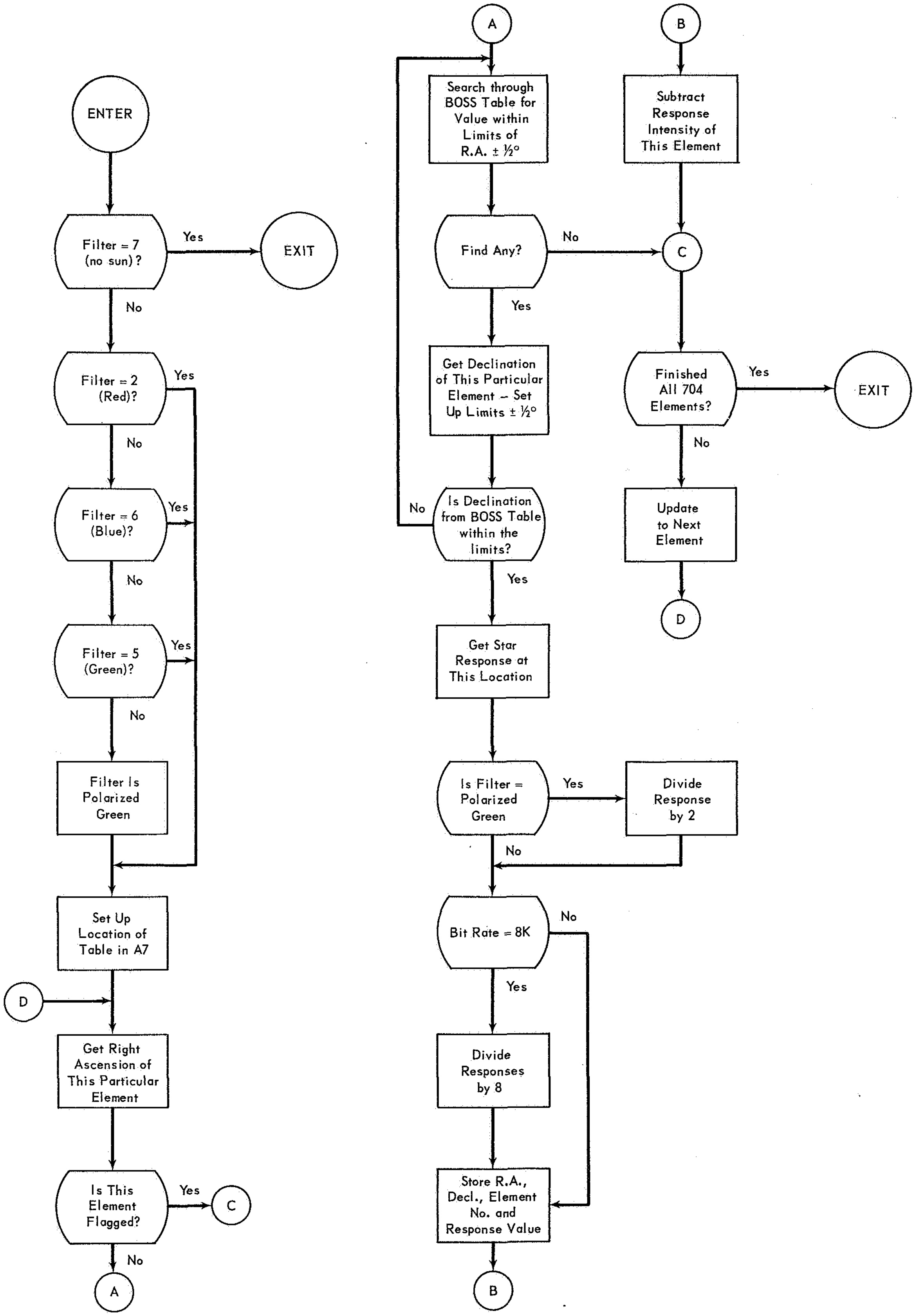
```
SLJ STARRY
```

Operational Description

1. Determine filter wheel position.
2. Exit if filter position 7 (no sun).
3. Set up location of table in A7 according to filter wheel position.
4. Get right ascension of element.
5. Increment to next element if this element is flagged.
6. Search BOSS table for a value within $\pm$ $1/2^{\circ}$ limit.
7. Increment to next element if no BOSS table entry is found.
8. Pick up declination and set up limits if entry is found.
9. Continue search through BOSS table if declination is not within $\pm$ $1/2^{\circ}$ limits.
10. Pick up star response when one is found within range.
11. Divide star response by 2 if polarized green filter is in position.
12. Divide star response by 8 if bit rate is 8K.
13. Store right ascension, declination, element number and response value.
14. Subtract response value from intensity of this element.
15. Increment to next element.
16. Exit when all 704 elements are finished.

Programs Used

None


ENTER
Filter = 7 (no sun)?
Yes
EXIT
No
Filter = 2 (Red)?
Yes
No
Filter = 6 (Blue)?
Yes
No
Filter = 5 (Green)?
Yes
No
Filter Is Polarized Green
Set Up Location of Table in A7
D
Get Right Ascension of This Particular Element
Is This Element Flagged?
Yes
C
No
A
A
Search through BOSS Table for Value within Limits of R.A. ± ½°
Find Any?
No
Yes
Get Declination of This Particular Element – Set Up Limits ± ½°
Is Declination from BOSS Table within the limits?
No
Yes
Get Star Response at This Location
Is Filter = Polarized Green
Yes
Divide Response by 2
No
Bit Rate = 8K
No
Yes
Divide Responses by 8
Store R.A., Decl., Element No. and Response Value
B
B
Subtract Response Intensity of This Element
C
Finished All 704 Elements?
Yes
EXIT
No
Update to Next Element
D

Function

Reads DECOM identification from tape.

Calling Sequence

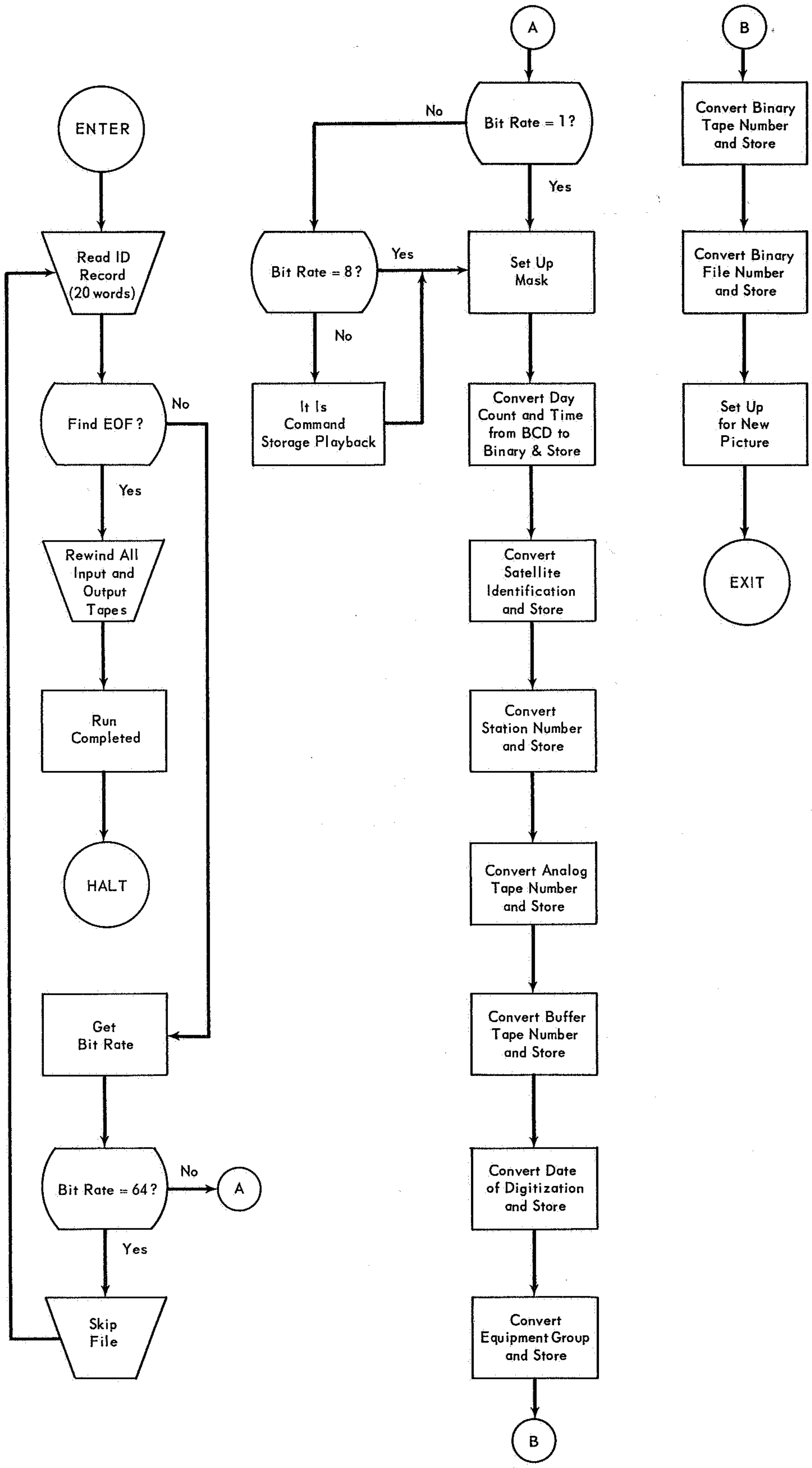
SLJ DECID

Operational Description

1. Read identification record (20 words).
2. Rewind all input/output tapes and halt when EOF is encountered.
3. Skip input file if bit rate is 64.
4. Determine command storage playback if bit rate is not 1 or 8.
5. Convert and store:
   a. Day count and time.
   b. Satellite identification.
   c. Station number.
   d. Analog tape number.
   e. Buffer tape number.
   f. Date of digitization.
   g. Equipment group.
   h. Binary tape and file number.
6. Initialize for new picture.
7. Exit.

Programs Used

MVFY1$	TPE$	TRI$
MVFY2$	KTYPE$	MEXIT$
TRF$	TEF$	EBCDB$


ENTER
Read ID Record (20 words)
Find EOF?
No
Yes
Rewind All Input and Output Tapes
Run Completed
HALT
Get Bit Rate
Bit Rate = 64?
No
A
Yes
Skip File
A
Bit Rate = 1?
No
Yes
Bit Rate = 8?
Yes
No
It Is Command Storage Playback
Set Up Mask
Convert Day Count and Time from BCD to Binary & Store
Convert Satellite Identification and Store
Convert Station Number and Store
Convert Analog Tape Number and Store
Convert Buffer Tape Number and Store
Convert Date of Digitization and Store
Convert Equipment Group and Store
B
B
Convert Binary Tape Number and Store
Convert Binary File Number and Store
Set Up for New Picture
EXIT

Function

Reads DECOM data from tape.

Calling Sequence

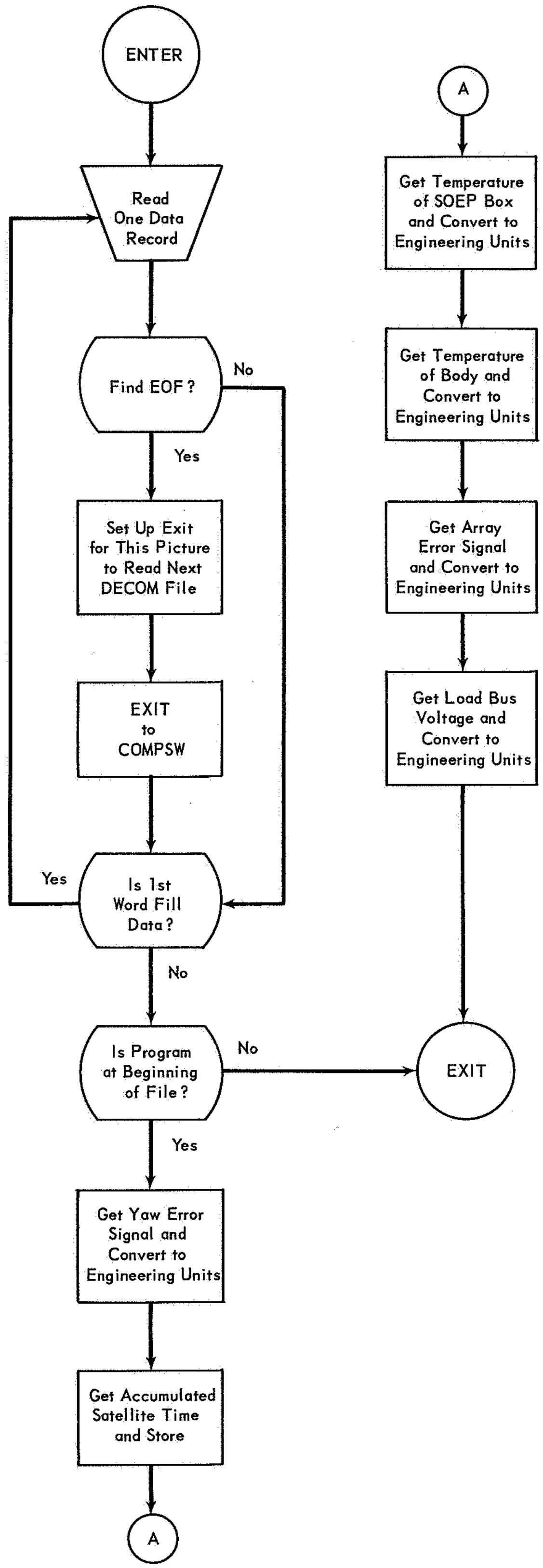
SLJ DECDAT

Operational Description

1. Read one data tape record.
2. Finalize and exit to COMPSW when EOF is encountered.
3. Test for fill data.
4. Exit if not at beginning of file.
5. Convert into engineering units and store:
   a. Yaw error signal.
   b. Accumulated satellite time.
   c. Temperature of SOEP box and body.
   d. Array error signal.
   e. Load bus voltage.
6. Exit.

Programs Used

MVFY1$
MVFY2$
TRF$


ENTER
Read One Data Record
Find EOF ?
No
Yes
Set Up Exit for This Picture to Read Next DECOM File
EXIT to COMPSW
Yes
Is 1st Word Fill Data ?
No
Is Program at Beginning of File ?
No
EXIT
Yes
Get Yaw Error Signal and Convert to Engineering Units
Get Accumulated Satellite Time and Store
A
A
Get Temperature of SOEP Box and Convert to Engineering Units
Get Temperature of Body and Convert to Engineering Units
Get Array Error Signal and Convert to Engineering Units
Get Load Bus Voltage and Convert to Engineering Units

Function

Reads attitude identification from tape.

Calling Sequence

SLJ ASPID

Operational Description

1. Read identification tape record.

2. Swap with next attitude tape when EOF is encountered.

3. Pick up start and end time for this file.

4. Print typewriter message (WRONG ASPECT TAPE) and exit when DECOM start time preceeds attitude start time.

5. Skip this file if DECOM start time follows attitude end time.

6. Convert and store day and time of:

    a. Yaw maneuver.

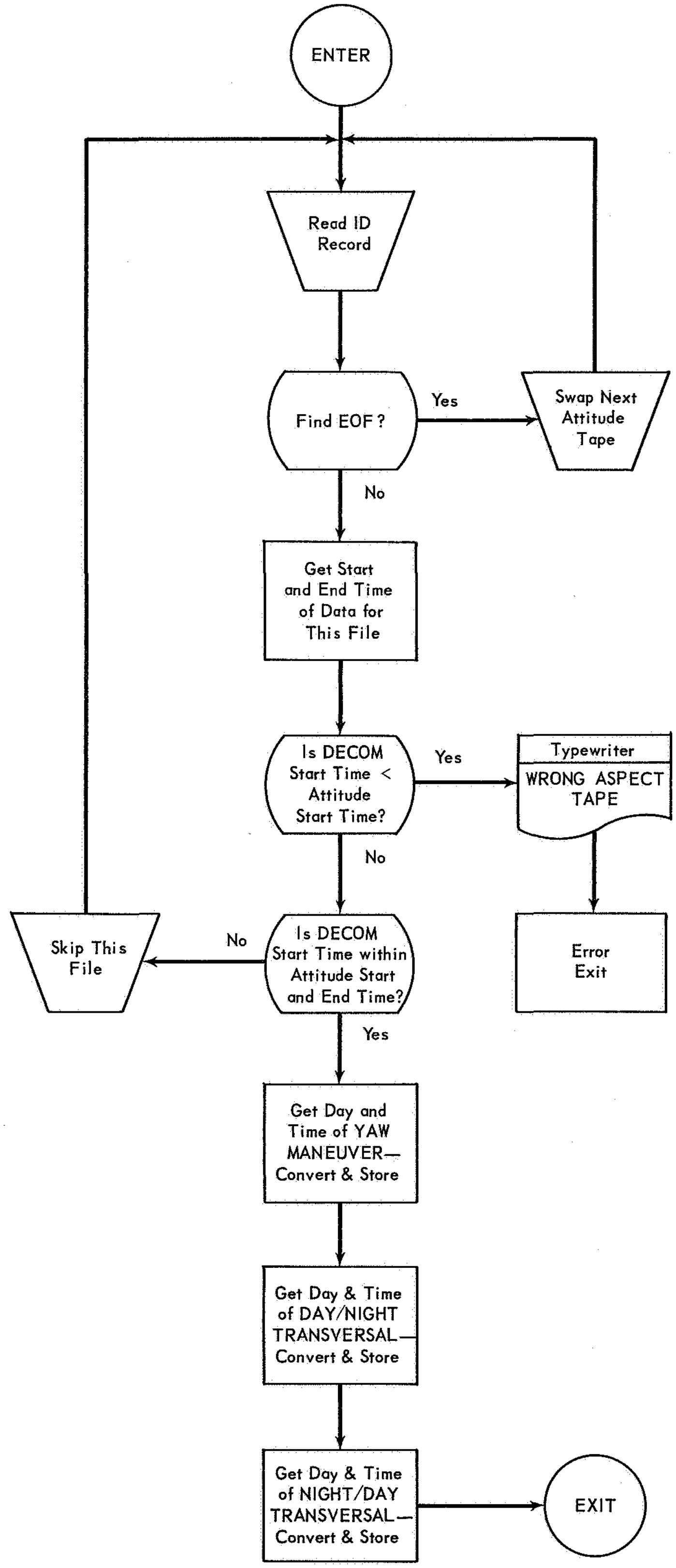
    b. Day - night transversal.

    c. Night - day transversal.

7. Exit.

Programs Used

MVFY1$	TPE$
MVFY2$	MERR$
TRF$	TSWAP$
FLTFIX	TESTD (entry DYTOMO)
KTYPE$	(entry HRMNSC)


ENTER
Read ID Record
Find EOF ?
Yes
Swap Next Attitude Tape
No
Get Start and End Time of Data for This File
Is DECOM Start Time < Attitude Start Time?
Yes
Typewriter
WRONG ASPECT TAPE
Error Exit
No
Is DECOM Start Time within Attitude Start and End Time?
No
Skip This File
Yes
Get Day and Time of YAW MANEUVER— Convert & Store
Get Day & Time of DAY/NIGHT TRANSVERSAL— Convert & Store
Get Day & Time of NIGHT/DAY TRANSVERSAL— Convert & Store
EXIT

Function

Reads attitude data from tape.

Calling Sequence

CALL SLJ ASPDAT

Operational Description

1. Skip this file and call ATTITUDE ID READ if start time of picture is not between start and end time of file.

2. Exit if new picture can use same data set as last picture.

3. Back up data tape 7 records, then read forward until match is located.

4. Pick up and store height, true anomaly and sun-earth-satellite angle.

5. Pick up, convert as required and store 15 groups (2 groups per record) of:

   a. Time (minutes).

   b. Orbital elements.

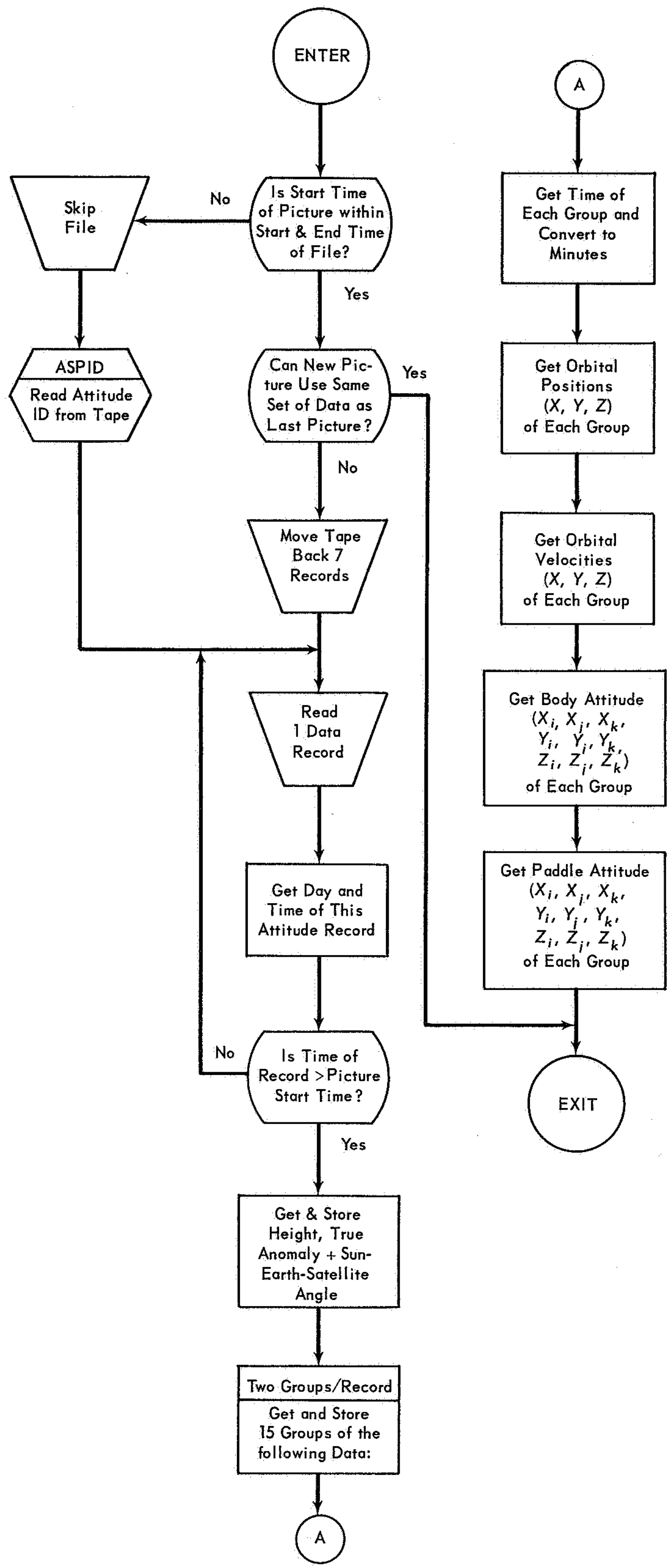
   c. Body attitude.

   d. Paddle attitude.

6. Exit.

Programs Used

TPB$	TRF$
TPE$	FLTFIX
ASPID	
MVFY1$	
MVFY2$	


ENTER
Is Start Time of Picture within Start & End Time of File?
No
Skip File
ASPID
Read Attitude ID from Tape
Yes
Can New Picture Use Same Set of Data as Last Picture?
Yes
No
Move Tape Back 7 Records
Read 1 Data Record
Get Day and Time of This Attitude Record
Is Time of Record > Picture Start Time?
No
Yes
Get & Store Height, True Anomaly + Sun-Earth-Satellite Angle
Two Groups/Record
Get and Store 15 Groups of the following Data:
A
A
Get Time of Each Group and Convert to Minutes
Get Orbital Positions (X, Y, Z) of Each Group
Get Orbital Velocities (X, Y, Z) of Each Group
Get Body Attitude (X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k) of Each Group
Get Paddle Attitude (X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k) of Each Group
EXIT

Function

Least squares quadratic solution. Also solves for angle β, rotates picture, computes RA and DEC for each element, and finally applies corrections if switch 5 is on.

Calling Sequence

```
LMJ   11,   LSQS      (21 COMMON names)
NOP   0
```

Operational Description

1. Set up 13 solved equations which are constant for all 9 groups of the picture:

   S_{0-4}, β_{12}, β_{13}, β_{22}, β_{23}, β_{32}, β_{33}, K_{23}, K_{33}

2. Solve for each of the 9 groups ($X_{i,j,k}$, $Y_{i,j,k}$, $Z_{i,j,k}$) the following:

   a. V_0, V_1, V_2

   b. β_{14}, β_{24}, β_{34}

   c. K_{24}, K_{34}

   d. C(J), B(J), A(J)

3. Compute time (T) for Xth element.

4. Skip to next picture element if this element is flagged.

5. Plug in time (T) of this element for each of the 9 least-squares-fit.

6. Compute attitude elements.

7. Rotate picture about Beta.

8. Find table values for X_g and Z_g for this element and convert to radians.

9. Determine quadrant.

10. Compute α(I) and δ (I).

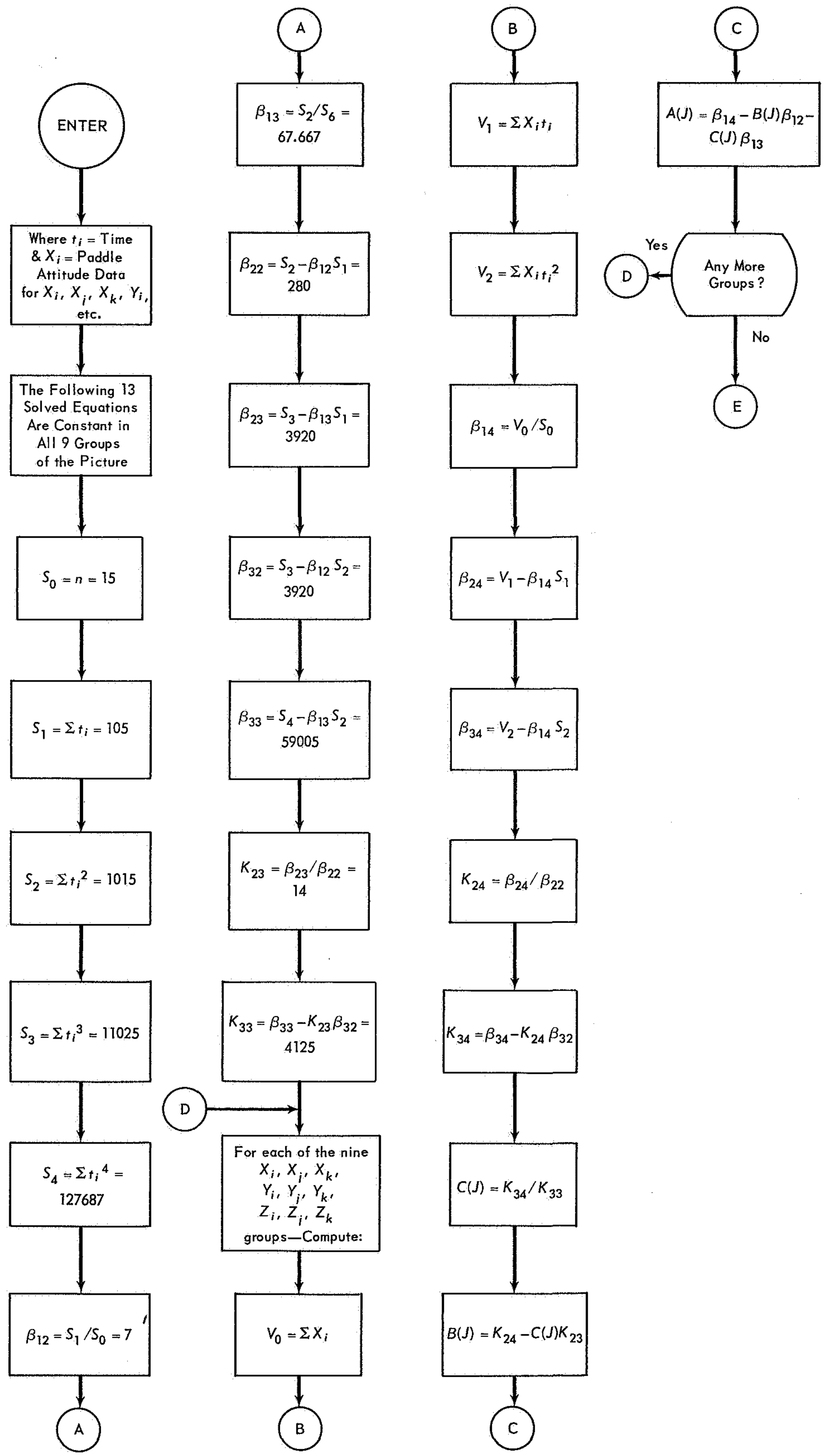
11. Add corrections to α(I) and δ(I) when switch 5 is on.

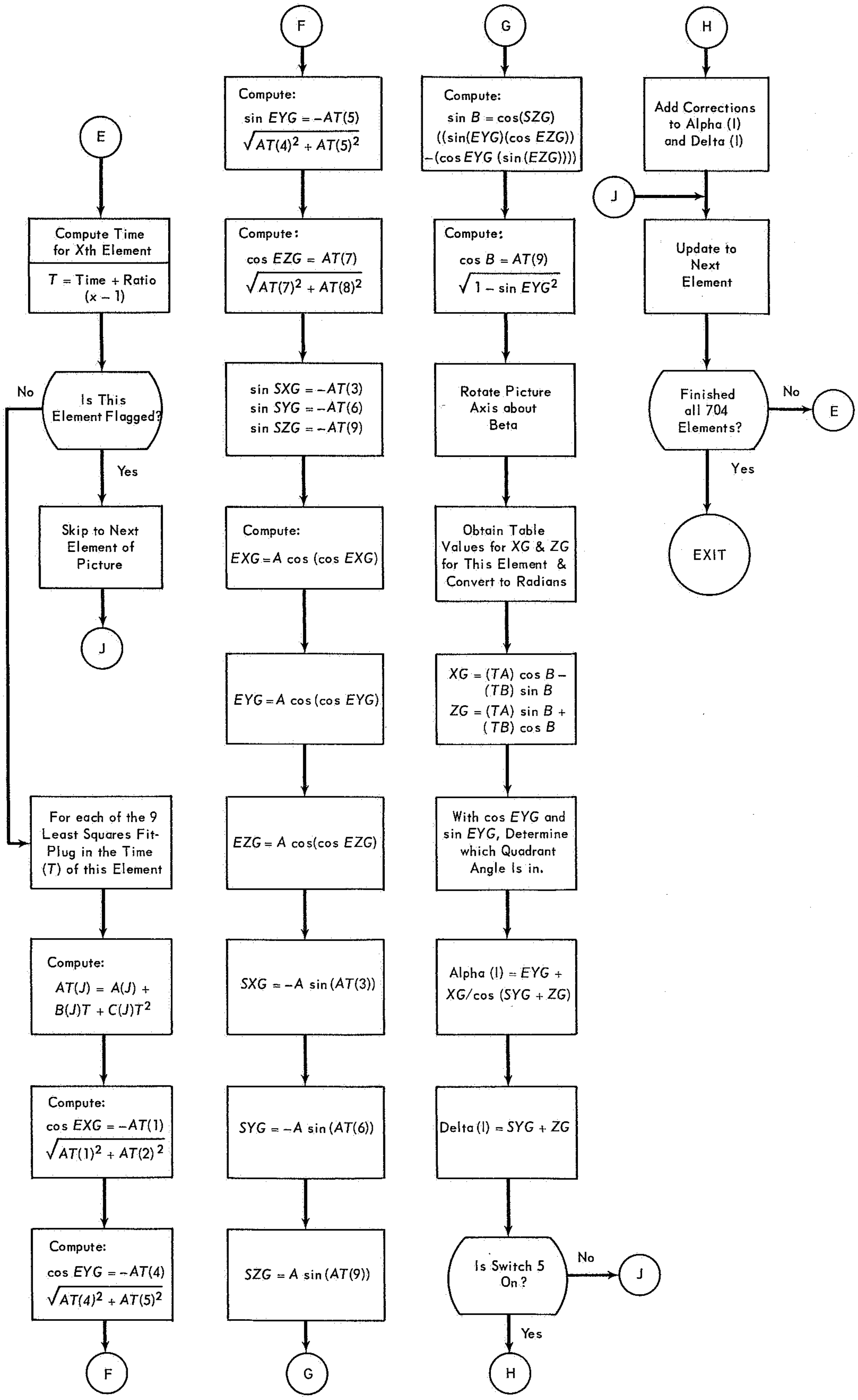
12. Increment to next element.

13. Exit when all 704 elements are finished.

Programs Used

SORT	NWDU$
ACOS	NIO1$
ASIN	NIO2$
COS	NSTCH$


ENTER
Where t_i = Time & X_i = Paddle Attitude Data for X_i, X_j, X_k, Y_i, etc.
The Following 13 Solved Equations Are Constant in All 9 Groups of the Picture
$S_0 = n = 15$
$S_1 = \Sigma t_i = 105$
$S_2 = \Sigma t_i^2 = 1015$
$S_3 = \Sigma t_i^3 = 11025$
$S_4 = \Sigma t_i^4 = 127687$
$\beta_{12} = S_1/S_0 = 7$
A
A
$\beta_{13} = S_2/S_6 = 67.667$
$\beta_{22} = S_2 - \beta_{12} S_1 = 280$
$\beta_{23} = S_3 - \beta_{13} S_1 = 3920$
$\beta_{32} = S_3 - \beta_{12} S_2 = 3920$
$\beta_{33} = S_4 - \beta_{13} S_2 = 59005$
$K_{23} = \beta_{23}/\beta_{22} = 14$
$K_{33} = \beta_{33} - K_{23}\beta_{32} = 4125$
D
For each of the nine X_i, X_j, X_k, Y_i, Y_j, Y_k, Z_i, Z_j, Z_k groups—Compute:
$V_0 = \Sigma X_i$
B
B
$V_1 = \Sigma X_i t_i$
$V_2 = \Sigma X_i t_i^2$
$\beta_{14} = V_0/S_0$
$\beta_{24} = V_1 - \beta_{14} S_1$
$\beta_{34} = V_2 - \beta_{14} S_2$
$K_{24} = \beta_{24}/\beta_{22}$
$K_{34} = \beta_{34} - K_{24}\beta_{32}$
$C(J) = K_{34}/K_{33}$
$B(J) = K_{24} - C(J)K_{23}$
C
C
$A(J) = \beta_{14} - B(J)\beta_{12} - C(J)\beta_{13}$
Any More Groups?
Yes
D
No
E


E
Compute Time for Xth Element
T = Time + Ratio (x – 1)
Is This Element Flagged?
No
Yes
Skip to Next Element of Picture
J
For each of the 9 Least Squares Fit-Plug in the Time (T) of this Element
Compute: AT(J) = A(J) + B(J)T + C(J)T²
Compute: cos EXG = –AT(1) √AT(1)² + AT(2)²
Compute: cos EYG = –AT(4) √AT(4)² + AT(5)²
F
F
Compute: sin EYG = –AT(5) √AT(4)² + AT(5)²
Compute: cos EZG = AT(7) √AT(7)² + AT(8)²
sin SXG = –AT(3)
sin SYG = –AT(6)
sin SZG = –AT(9)
Compute: EXG = A cos (cos EXG)
EYG = A cos (cos EYG)
EZG = A cos(cos EZG)
SXG = –A sin (AT(3))
SYG = –A sin (AT(6))
SZG = A sin (AT(9))
G
G
Compute: sin B = cos(SZG) ((sin(EYG)(cos EZG)) –(cos EYG (sin(EZG))))
Compute: cos B = AT(9) √1 – sin EYG²
Rotate Picture Axis about Beta
Obtain Table Values for XG & ZG for This Element & Convert to Radians
XG = (TA) cos B – (TB) sin B
ZG = (TA) sin B + (TB) cos B
With cos EYG and sin EYG, Determine which Quadrant Angle Is in.
Alpha (I) = EYG + XG/cos (SYG + ZG)
Delta (I) = SYG + ZG
Is Switch 5 On?
No
J
Yes
H
H
Add Corrections to Alpha (I) and Delta (I)
J
Update to Next Element
Finished all 704 Elements?
No
E
Yes
EXIT

ROTATE (Fortran IV)

Function

Rotates right ascension and declination for every picture element into ecliptic coordinates.

Calling Sequence

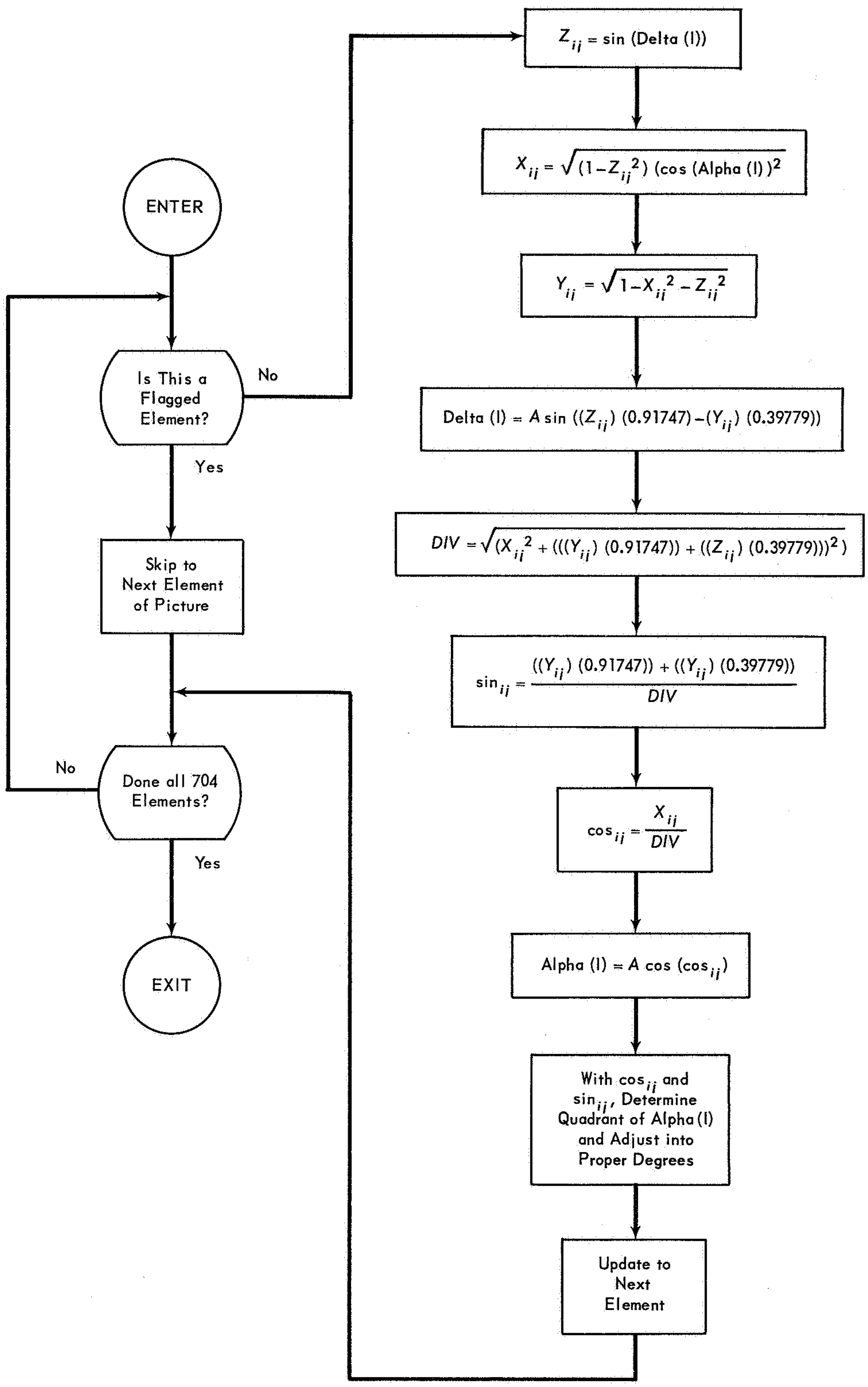
LMJ 11, ROTATE
NOP 0 (15 COMMON names)

Operational Description

1. Increment to next element if this element is flagged.
2. Compute X_{ij}, Y_{ij}, Z_{ij}.
3. Compute δ(I), α(I).
4. Determine quadrant for α(I) and convert into degrees.
5. Exit when all 704 elements are finished.

Programs Used

SIN
SORT
COS
ASIN
ACOS


ENTER
Is This a Flagged Element?
No
Yes
Skip to Next Element of Picture
Done all 704 Elements?
No
Yes
EXIT
Z_{ij} = sin (Delta (I))
$X_{ij} = \sqrt{(1-Z_{ij}^2)(\cos(\text{Alpha}(I))^2}$
$Y_{ij} = \sqrt{1-X_{ij}^2-Z_{ij}^2}$
Delta (I) = A sin $((Z_{ij})(0.91747)-(Y_{ij})(0.39779))$
$DIV = \sqrt{(X_{ij}^2+(((Y_{ij})(0.91747))+((Z_{ij})(0.39779)))^2)}$
$\sin_{ij} = \frac{((Y_{ij})(0.91747))+((Y_{ij})(0.39779))}{DIV}$
$\cos_{ij} = \frac{X_{ij}}{DIV}$
Alpha (I) = A cos $(\cos_{ij})$
With $\cos_{ij}$ and $\sin_{ij}$, Determine Quadrant of Alpha (I) and Adjust into Proper Degrees
Update to Next Element

OUTPUT (Fortran IV)

Function

Writes output on high speed printer and tape.

Calling Sequence

LMJ	OUTPUT	(23 COMMON names)
NOP	0	

Operational Description

1. Write unit 28 (on-line):

   a. ID record, DECOM identification and filter wheel position.

   b. Start and end time of picture and eclipse. Time of yaw maneuver and accumulated satellite time.

   c. Temperature of SOEP box and body package, load bus voltage.

   d. Yaw error, array error, true anomaly, height and sun-earth-satellite angle.

   e. Body and paddle attitude.

   f. Orbital positions and velocities.

   g. Right ascension, declination, corrected and raw intensity.

2. Write on-line whenever starry background was subtracted:

   a. Element number, right ascension, and declination.

   b. Starry background subtracted.

3. Write 5 records on tape 13:

   a. Record 1 - ID information

   b. Record 2 - ID and right ascension

   c. Record 3 - ID and declination

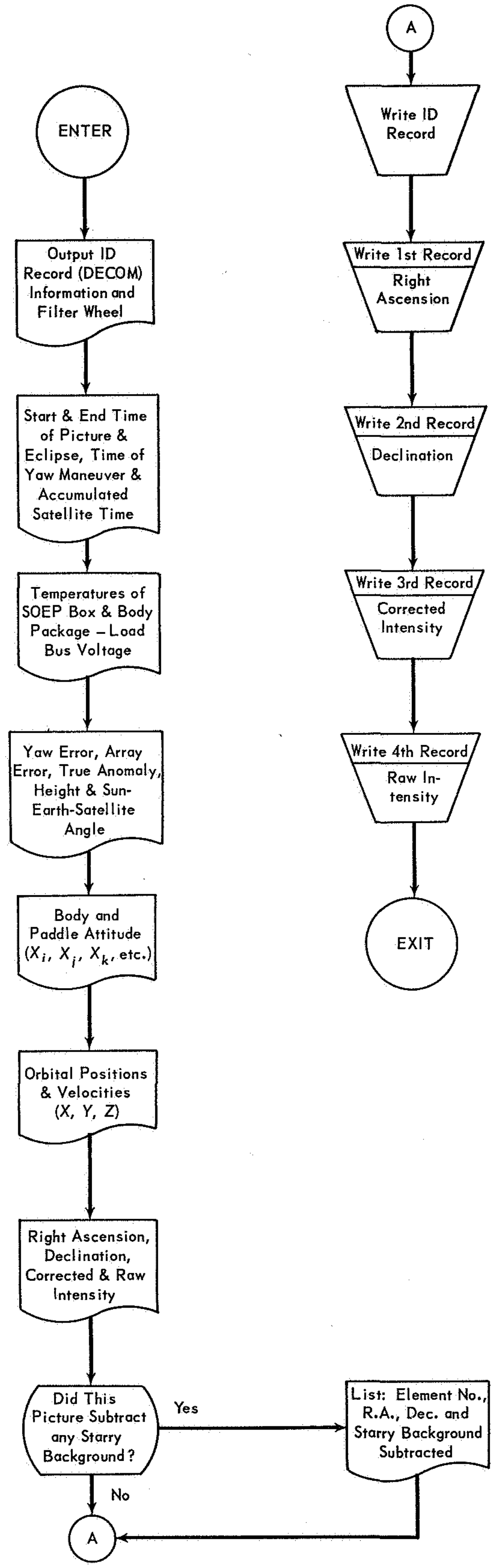
d. Record 4 - ID and corrected intensity

e. Record 5 - ID and raw intensity

4. Exit.

Programs Used

NWDU$	NIO2$	NWBT$
	NIO1$	NWEF$


ENTER
Output ID Record (DECOM) Information and Filter Wheel
Start & End Time of Picture & Eclipse, Time of Yaw Maneuver & Accumulated Satellite Time
Temperatures of SOEP Box & Body Package – Load Bus Voltage
Yaw Error, Array Error, True Anomaly, Height & Sun-Earth-Satellite Angle
Body and Paddle Attitude (X_i, X_j, X_k, etc.)
Orbital Positions & Velocities (X, Y, Z)
Right Ascension, Declination, Corrected & Raw Intensity
Did This Picture Subtract any Starry Background?
Yes
List: Element No., R.A., Dec. and Starry Background Subtracted
No
A
A
Write ID Record
Write 1st Record
Right Ascension
Write 2nd Record
Declination
Write 3rd Record
Corrected Intensity
Write 4th Record
Raw Intensity
EXIT

DISPLAY PROGRAM

COMPUTATION PROCEDURE

The Display Program is designed to provide a convenient tool for presenting large volumes of gegenschein experiment data in a time-sequenced motion picture. The program is written in Fortran IV language for the Univac 1107-08 computer and uses the SC 4020 software package developed by Computer Sciences Corporation.

Computation is performed in three separate phases, which are not necessarily three separate machine runs. In the first phase, experiment data is subjected in time sequence to a filtering process where unrecognizable data frames are eliminated. Valid frames are written onto a Photo Tape, which serves as a collection pool for the frame data; approximately 700 frames may be contained by the tape. In addition, cards (Frame Edit Cards) are punched for use in controlling the remaining processing phases.

In the second phase, the data on the Photo Tape is converted SC 4020 instructions for visual presentation. Each resulting picture frame contains, in addition to the grid labels, a frame number, the picture time in days and seconds, the filter number, and the true anomaly value in degrees. During this phase, frames are edited according to specifications entered in program control cards, to compensate for wide ranging intensity levels or picture skewness.

In the third phase, the data generated in the second phase is duplicated on tape for use with the SC 4020 in producing a 35 mm. movie film.

Name	Code	Description
GEGEN	Fortran	Main Program - Display Program
PICTUR	Fortran	Preprocessing for FRAME
FRAME	Fortran	Plots Data with Overlays
GRITE	Fortran	Buffer SC 4020 Output
PLOTV	Sleuth	Plots SC 4020 Characters
LINEAR	Fortran	Linear Interpolation
BSTAT	Fortran	Decode NTRAN Status Flag
MOVE	Fortran	Initiate a read or write of 5 records
GVANCE	Sleuth	Identification for SC 4020
GCLOK	Fortran	Print Elapsed Time
NTAB$		I/O Channel Allocator

GEGEN (Fortran)

Function

This is the main routine for the Gegenschein Display Program. It functions as a main control in addition to preparing the Photo Tape from one or more gegenschein tapes.

Calling Sequence

None

Operational Description

1. Reads and prints six Basic Input Cards.

2. Reads star data, milky way data, and gegenschein tapes (if present).

3. Performs validity check on gegenschein data; buffers out photometry data to the Photo Tape at the designated start point and punches Display Edit Cards containing frame numbers.

4. Reads a Display Edit Card.

5. Buffers in the appropriate photometer frame to an available buffer bank and calls PICTUR.

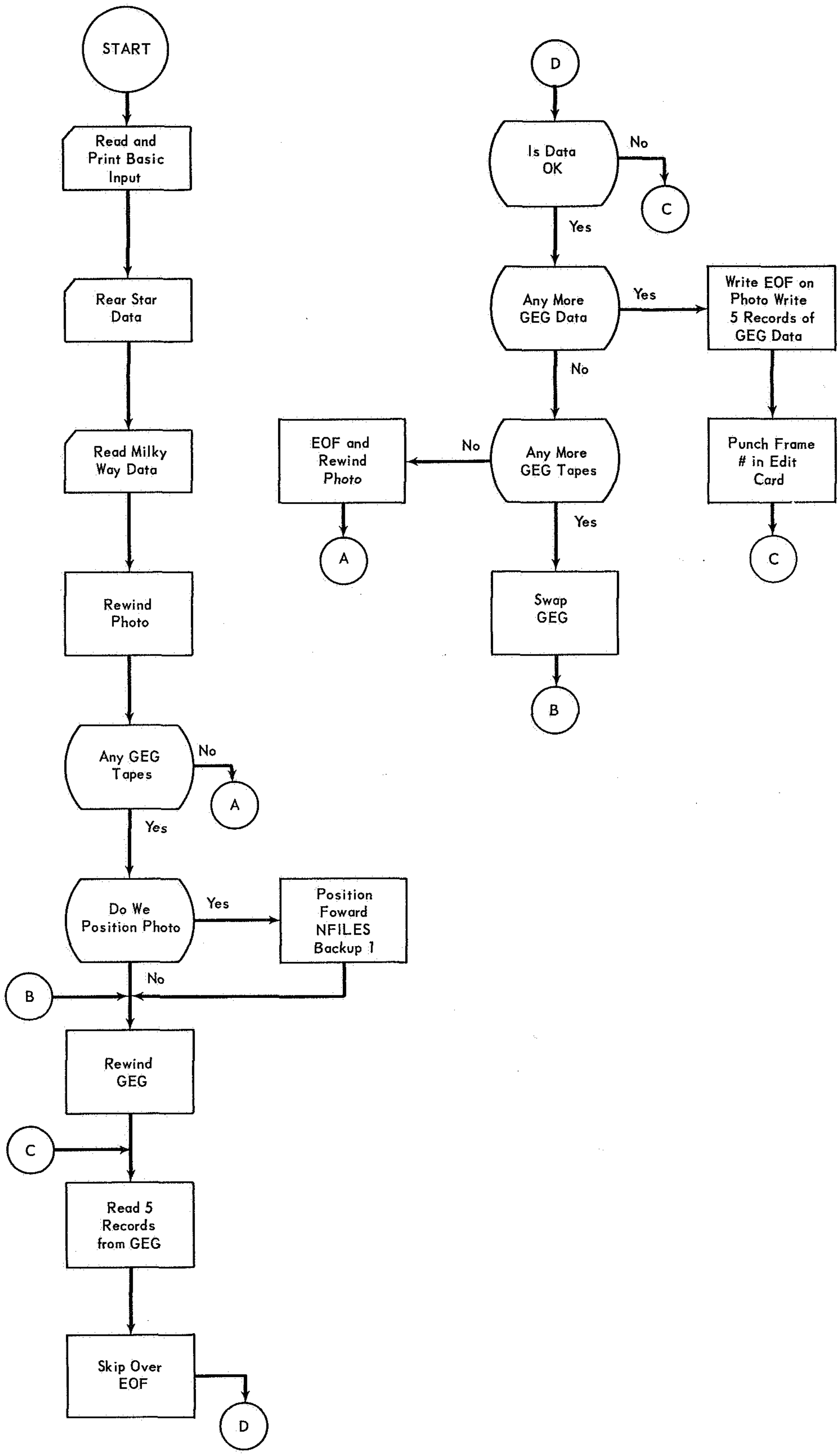
6. Returns to (4) until no Display Edit Cards remain.

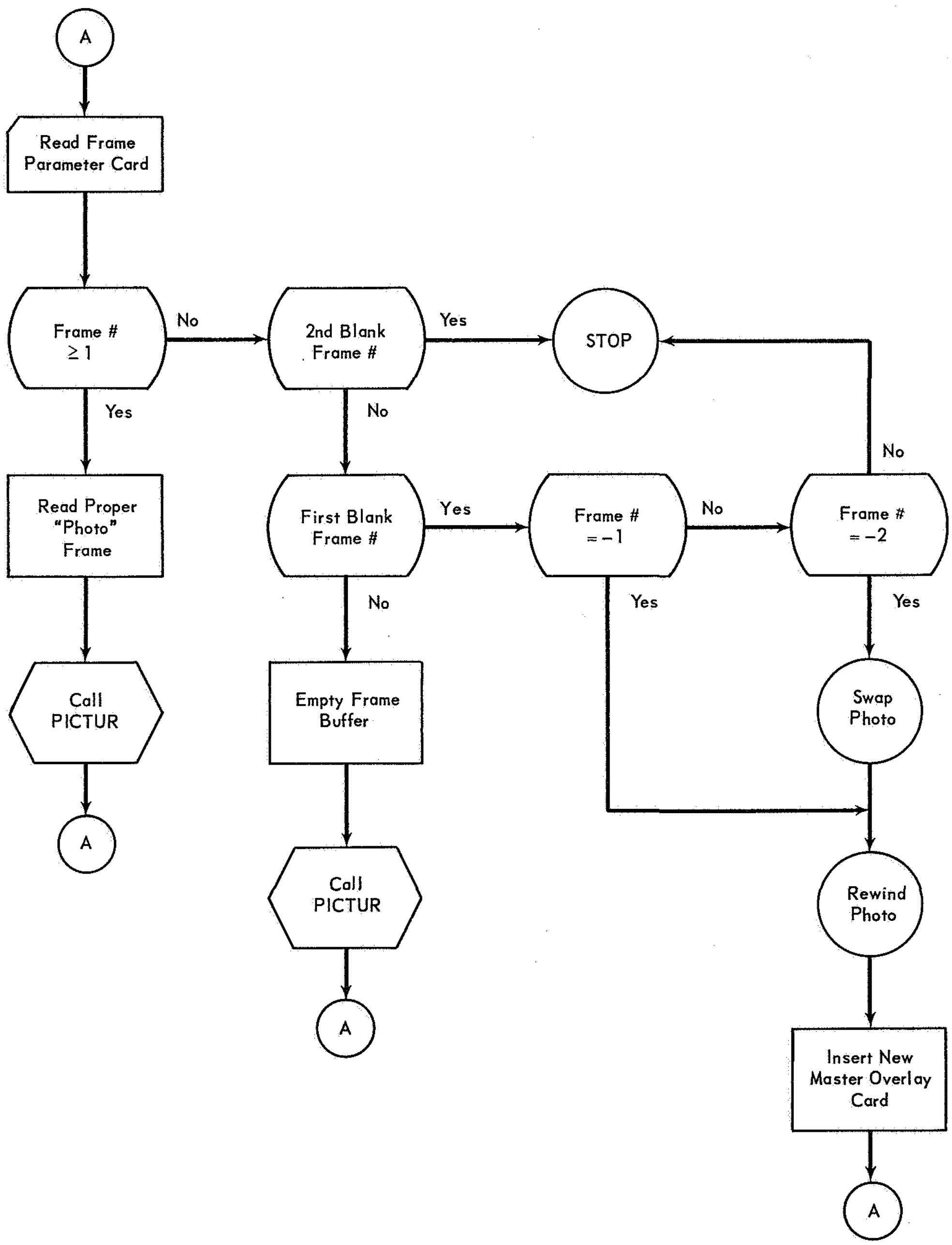
7. STOPS.

Note: Steps 4 and 5 are handled in a flip-flop bufferec fashion.

Programs Used

MOVE
NTRAN
BSTAT
PICTUR
GVANCE
BUFFER
LETTER


START
Read and Print Basic Input
Rear Star Data
Read Milky Way Data
Rewind Photo
Any GEG Tapes
No
A
Yes
Do We Position Photo
Yes
Position Foward NFILES Backup 1
No
B
Rewind GEG
C
Read 5 Records from GEG
Skip Over EOF
D
D
Is Data OK
No
C
Yes
Any More GEG Data
Yes
Write EOF on Photo Write 5 Records of GEG Data
Punch Frame # in Edit Card
C
No
Any More GEG Tapes
No
EOF and Rewind Photo
A
Yes
Swap GEG
B


A
Read Frame Parameter Card
Frame # ≥ 1
No
Yes
Read Proper "Photo" Frame
Call PICTUR
A
2nd Blank Frame #
Yes
No
STOP
First Blank Frame #
Yes
No
Empty Frame Buffer
Call PICTUR
A
Frame # = −1
No
Yes
Frame # = −2
No
Yes
Swap Photo
Rewind Photo
Insert New Master Overlay Card
A

PICTUR (Fortran)

Function

Performs preprocessing for FRAME.

Calling Sequence

CALL PICTUR (IBANK)

where IBANK is the buffer bank number; all other necessary data is obtained through named common.

Operational Description

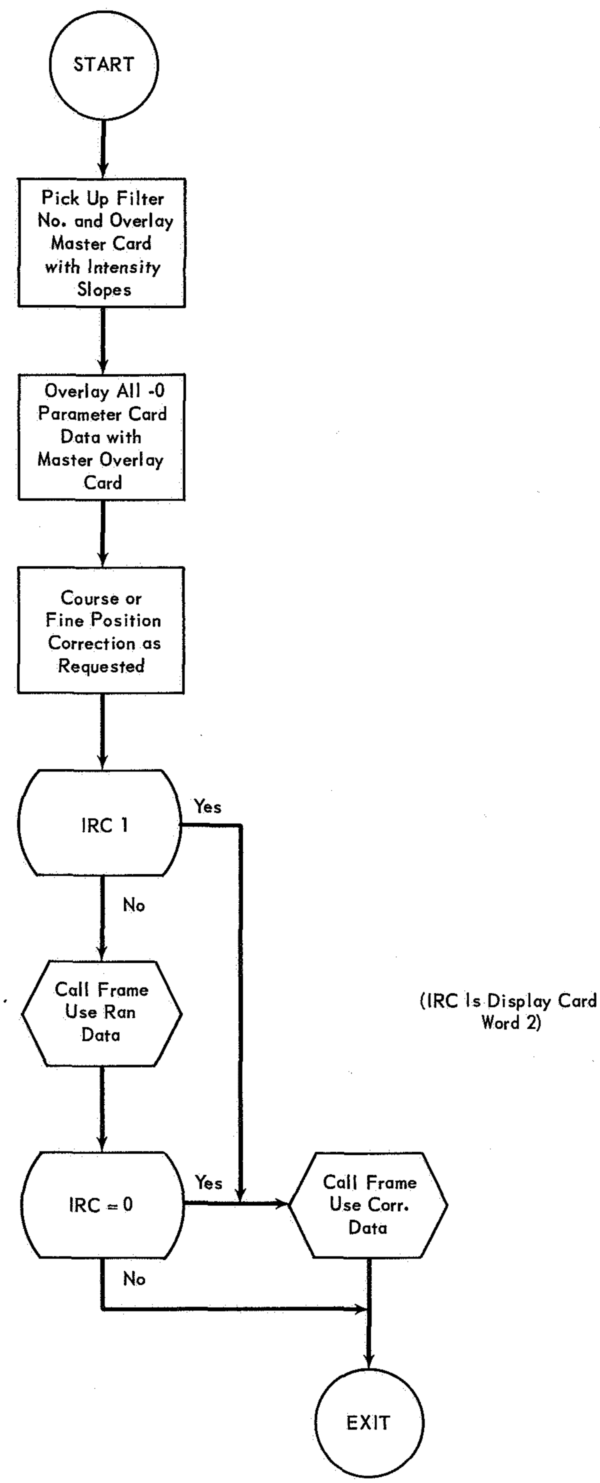
1. Merges Display Edit Card data with the Master Overlay Card data.

2. Performs fine or coarse position correction if requested.

3. Makes appropriate call or calls to FRAME.

Programs Used

FRAME


START
Pick Up Filter No. and Overlay Master Card with Intensity Slopes
Overlay All -0 Parameter Card Data with Master Overlay Card
Course or Fine Position Correction as Requested
IRC 1
Yes
No
Call Frame Use Ran Data
IRC = 0
Yes
No
Call Frame Use Corr. Data
EXIT
(IRC Is Display Card Word 2)

FRAME (Fortran)

Function

Plots gegenschein photometry data with the designated overlays.

Calling Sequence

CALL FRAME (IBANK, IRC)

where IBANK is the Buffer data number: 1 = bank 1
2 = bank 2

IRC is the type data flag: 1 = raw data
2 = corrected data

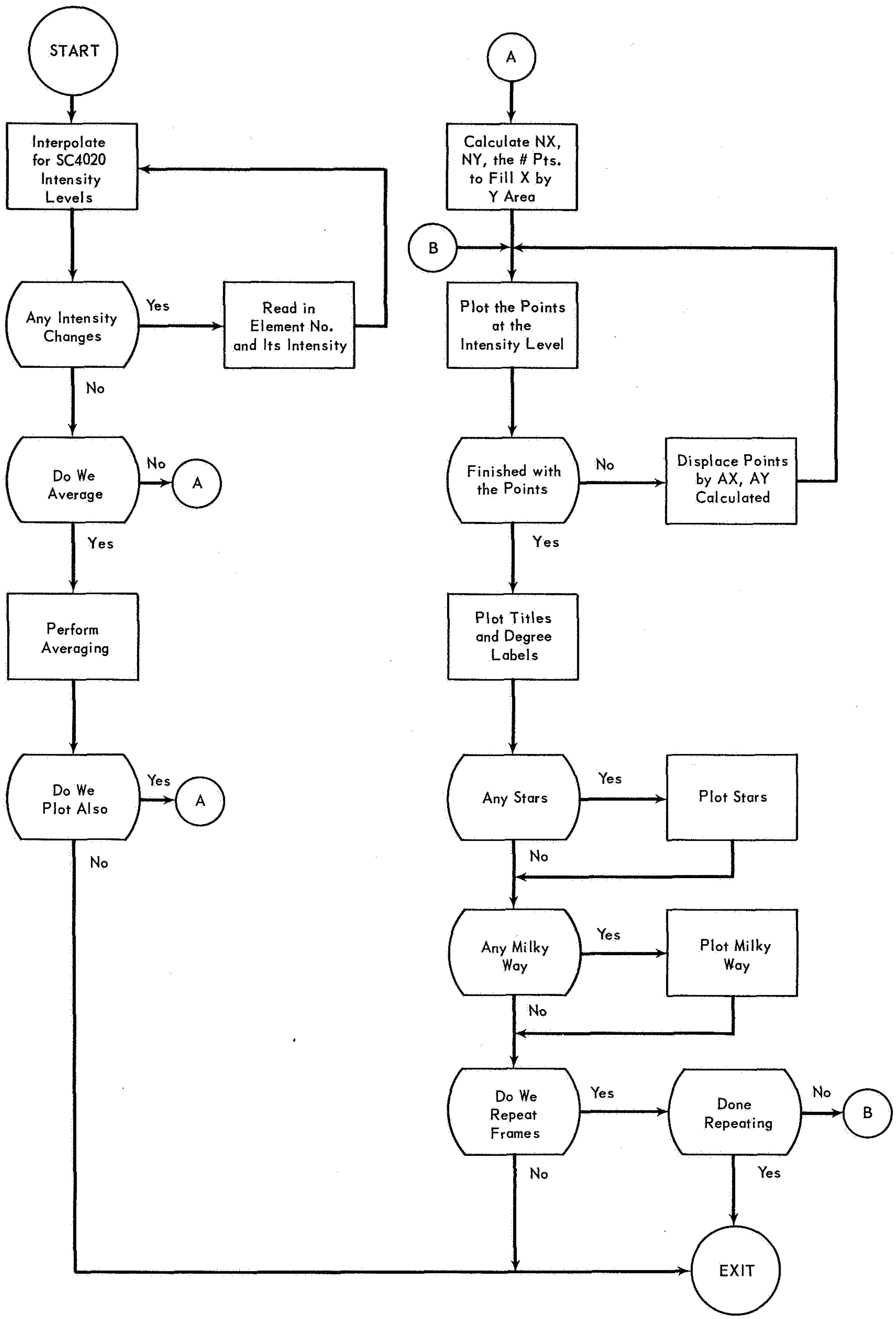
Other necessary data is obtained through named common.

Operational Description

1. Pick up data from correct bank and print elapsed time if indicated.
2. Pick up raw or corrected data intensities.
3. Interpolate intensity data and perform averaging if requested.
4. Read in intensity modifications, if any.
5. Calculate the necessary number and spacing between the plot points which will cover the $X^o \times Y^o$ area.
6. Plot the points at the designated intensity level.
7. Overlay axis titles, degree markers, frame number, etc.
8. Advance film.
9. Return to (6) if repeat frames are requested; otherwise return.

Programs Used

LINEAR	LETTER	BUFFER
PLOTV	SET	GCLOK
PLOTVL	GVANCE	


START
Interpolate for SC4020 Intensity Levels
Any Intensity Changes
Yes
Read in Element No. and Its Intensity
No
Do We Average
No
A
Yes
Perform Averaging
Do We Plot Also
Yes
A
No
A
Calculate NX, NY, the # Pts. to Fill X by Y Area
B
Plot the Points at the Intensity Level
Finished with the Points
No
Displace Points by AX, AY Calculated
Yes
Plot Titles and Degree Labels
Any Stars
Yes
Plot Stars
No
Any Milky Way
Yes
Plot Milky Way
No
Do We Repeat Frames
Yes
Done Repeating
No
B
Yes
No
EXIT

GRITE (Fortran)

Function

Buffer SC 4020 instructions to output tape using NTRAN.

Calling Sequence

CALL GRITE (BADD, IS, IC)

where:

BADD	is the buffer address defined with a call to BUFFER (CSC plot package).
IS	is buffer size.
IC	is "count" the number of words to buffer out.

Operational Description

The single call to GRITE has replaced the tape write sequence of routine RITE in the CSC plot package. The resulting buffered output from GRITE is identical to that produced by RITE and is, therefore, compatible with the SC 4020 hardware. Additional parameters required by GRITE are entered via named common:

LB - an array for NTRAN status flags

LS - the number of variable sized buffers

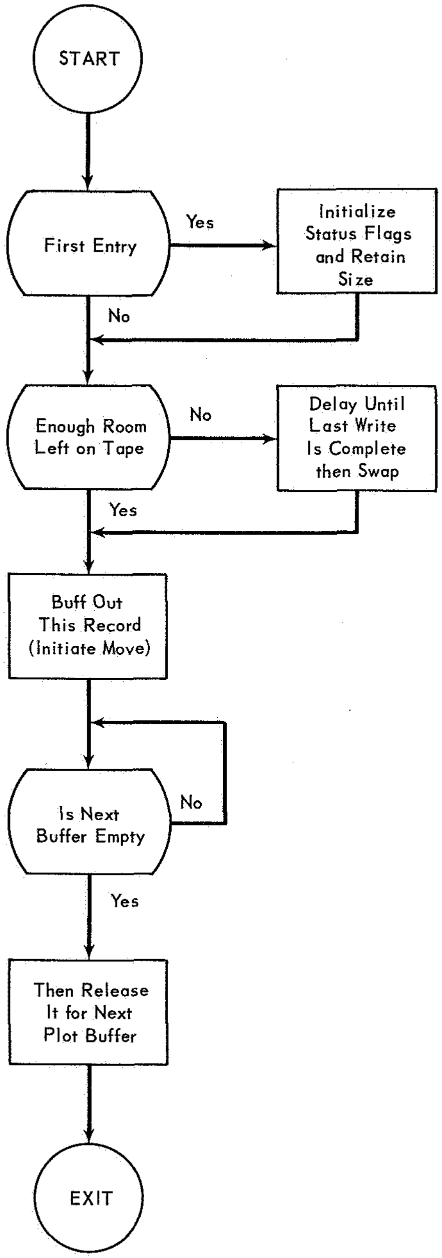
ITOL - the number of words output prior to tape swapping

IPLOT - the output tape unit

While a call to GRITE is never initiated by the user, the buffer may be unloaded by the call to RITE as before.

Programs Used

NTRAN
BSTAT



(Only after Encountering
Advance Instruction)

Tape Error Procedure:

1. Release Error Unit
2. Write EOF
3. Rewind with Interlock
4. Swap Next Reel
5. Rewind It

Tape Swap Procedure:

1. Write EOF
2. Rewind with Interlock
3. Swap to Next Reel
4. Rewind It

PLOTV (Sleuth)

Function

Plots an SC 4020 character at a specified intensity level.

Calling Sequence

CALL PLOTV (BUF, N, X, Y, DELX, DELY, IHC, ISCALE, I)

where:

I is the address of the intensity level array.

For detailed discussion on the remaining parameters, consult the Computer Sciences Corporation Users Manual for the UNIVAC 1107 linked SC 4020 microfilm recorder.

Operational Description

An additional entry to the CSC plot package has been incorporated to utilize the specified intensity plot command (OPCODE 01).

Programs Used

PLOTP
BOOK

LINEAR (Fortran)

Function

Linear interpolation.

Calling Sequence

CALL LINEAR (IX, IY, IXO, IYO, IXI, IYI, INUM)

where:

IX is the input array.

IY is the resulting output after interpolating.

INUM is the array length.

Operational Description

This routine is used for intensity interpolation where the Y values relate to SC 4020 intensities and the X values to data intensities as,

A = (IYI - IY0) / (IXI - IX0).

Then for each IX,

IY = IY0 + A (IX - IX0)

BSTAT (Fortran)

Function

From the NTRAN status flag, determine the appropriate transfer.

Calling Sequence

CALL BSTAT (J, \$SN1, \$SN2, \$SN3, \$SN4, \$SN5)

where:

J is the status flag to be tested

SN_i are statement numbers to which a transfer is made as follows:

SN1	if $J \geq 0$
SN2	if $J = -1$
SN3	if $J = -2$
SN4	if $J = -3$
SN5	if $J = -4$

(STOP is executed if none of the above conditions exist).

Programs Used

NONE

MOVE (Fortran)

Function

Initiate a read or write of five records.

Calling Sequence

CALL MOVE (D1, D2, D3, D4, D5, IS, ITAPE, IDIR)

where:

D1 - D5	are data record addresses whose length is fixed at compile time.
IS	is an array for the status flags.
ITAPE	is the tape number to or from which data is moved.
IDIR	is the movement direction: 1 = buffered write 2 = buffered read

Operational Description

This special-purpose routine was written to buffer gegenschein data in and out.

Programs Used

NTRAN

GVANCE (Sleuth)

Function

Adds an identification integer to the SC 4020 advance instruction prior to its insertion in the plot output buffer.

Calling Sequence

CALL GVANCE (BUF, N)

where:

BUF is the buffer address (see routine VANCE).

N is the integer to be added.

Programs Used

VANCE

GCLOK (Fortran)

Function

Prints elapsed time in seconds between calls.

Calling Sequence

CALL GCLOK (I, J)

where:

I is current time in seconds obtained in subroutine GCLOK from a call to GCL (Sleuth).

J is the execution flag; designated > 0 for execution.

Programs Used

GCL

NTAB$

Function

Channel allocator as:

```
        +3
        +2
        +1
NTAB$*  +'A'
        +'B'
        +'C'
        +'D'
        +'E'
        +'F'
        END
```

Note: Various routines were modified to remove plot constraint of (120 - 127). A small additional change will complete the plot tape variability.

FILTER RESPONSE PROGRAM

The Filter Response Program was created to compute the theoretical response of the gegenschein photometer to various star types for each of the colored filters. The program is not a part of the Gegenschein Analysis System (i.e., the production system). The results of the program were used, after manual interpolation, to create the Star Table Tape used by the Gegenschein Processing Program.

COMPUTATIONAL PROCEDURE

The program evaluates the following integral,

$$\int_{\lambda_1}^{\lambda_n} I(\lambda)\, t(\lambda)\, \delta(\lambda)$$

where:

$$I(\lambda) = \frac{x^5 e^{-x}}{21.201}$$

$$x = \frac{1.43868 \times 10^4}{\lambda T}$$

λ = wave length of the filter as follows:

Filter 1: 0.224u to 0.356u
Filter 2: 0.400u to 0.640u
Filter 3: 0.650u to 0.850u

T = temperature to be used for each filter as follows (the type of star is directly proportional to its temperature):

(1) 70000°K	(9) 13000	(17) 5400
(2) 60000	(10) 11000	(18) 4800
(3) 50000	(11) 9000	(19) 4200
(4) 40000	(12) 8200	(20) 3800
(5) 38000	(13) 7400	(21) 3200
(6) 30000	(14) 6700	(22) 2800
(7) 22000	(15) 6300	(23) 2400
(8) 15400	(16) 5800	(24) 2000

t = value of $t_i(\lambda)$ for the filter.

The program loops through three sets of λ's (one for each filter) and evaluates each set for all 24 temperatures (T). For each filter, the integral is evaluated in increments of .004 between the limits of λ.

The program produces a printout of the computed integral for each temperature (T) for each filter (Figures 5-7, 5-8, and 5-9) and a table of color temperatures by spectral type (Figure 5-10). The Boss General Catalogue of Stars, which is contained on a set of magnetic tapes, was then input to another program along with the evaluations of the integral for the various spectral types of stars. This program remade the Boss Catalogue into a catalogue of stars as the photometer would see them by applying the following equation to each star:

$$R = a \cdot T_c \cdot 10^{-2/5m} \cdot I_f(T_c)$$

where: R = photometer response in counts/picture element.

m = apparent visual magnitude in Boss Catalogue.

T_c = color temperature of star.

a = constant chosen such that a star of visual magnitude +5 and spectral type GO gives a response in the green filter of 4400 counts/picture element at the 1Kb rate.

$I_f(T_c)$ = value of integral (for each filter).

Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)
05	.00000012	A5	.00026529	G5	.00130636
06	.00000024	A6	.00032592	G6	.00133940
07	.00000045	A7	.00035883	G7	.00137244
08	.00000080	A8	.00041368	G8	.00140549
09	.00000142	A9	.00044659	G9	.00143553
B0	.00000205	F0	.00049052	K0	.00149561
B1	.00000393	F1	.00055876	K1	.00155569
B2	.00000534	F2	.00060994	K2	.00160387
B3	.00000969	F3	.00064881	K3	.00164011
B4	.00001554	F4	.00071433	K4	.00165823
B5	.00001944	F5	.00077985	K5	.00167635
B6	.00003105	F6	.00082854	K6	.00169447
B7	.00004560	F7	.00088224	K7	.00169102
B8	.00006015	F8	.00093594	K8	.00168757
B9	.00007470	F9	.00098964	K9	.00168541
A0	.00008841	G0	.00105036	M0	.00165001
A1	.00012086	G1	.00111108	M1	.00159691
A2	.00014446	G2	.00117598	M2	.00154381
A3	.00017919	G3	.00120843	M3	.00150841
A4	.00022511	G4	.00124088	M4	.00143500
				M5	.00132160

Figure 5-7. Table of Integral (IF (Tc)) for Various Spectral Type (ST) Red Filter

Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)
05	.00002724	A5	.00559784	G5	.00229577
06	.00004955	A6	.00561868	G6	.00215419
07	.00008613	A7	.00561077	G7	.00201261
08	.00013837	A8	.00559747	G8	.00187102
09	.00022687	A9	.00558949	G9	.00174251
B0	.00030949	F0	.00557885	K0	.00148549
B1	.00033403	F1	.00537829	K1	.00122847
B2	.00065308	F2	.00522785	K2	.00100233
B3	.00097016	F3	.00509288	K3	.00080705
B4	.00137216	F4	.00483843	K4	.00070941
B5	.00164012	F5	.00458396	K5	.00061177
B6	.00209619	F6	.00438285	K6	.00051415
B7	.00257930	F7	.00415027	K7	.00041785
B8	.00306240	F8	.00391769	K8	.00032155
B9	.00354551	F9	.00368511	K9	.00025720
A0	.00394351	G0	.00341642	M0	.00022420
A1	.00442489	G1	.00314773	M1	.00017470
A2	.00477495	G2	.00286357	M2	.00012520
A3	.00508631	G3	.00272149	M3	.00009220
A4	.00535911	G4	.00257941	M4	.00005373
				M5	.00003693

Figure 5-8. Table of Integral (IF (Tc)) for Various Spectral Types (ST) Blue Filter

Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)	Spectral Type (ST)	Integral IF (Tc)
05	.00000115	A5	.00134544	G5	.00335166
06	.00000221	A6	.00155464	G6	.00334894
07	.00000409	A7	.00166552	G7	.00334622
08	.00000701	A8	.00185032	G8	.00334350
09	.00001222	A9	.00196120	G9	.00330886
B0	.00001738	F0	.00210899	K0	.00323950
B1	.00003190	F1	.00229047	K1	.00317030
B2	.00004279	F2	.00242658	K2	.00305341
B3	.00007363	F3	.00251850	K3	.00288887
B4	.00011443	F4	.00265827	K4	.00280660
B5	.00014163	F5	.00279804	K5	.00272433
B6	.00021222	F6	.00288639	K6	.00264205
B7	.00029772	F7	.00296989	K7	.00245800
B8	.00038322	F8	.00305339	K8	.00227395
B9	.00046872	F9	.00313689	K9	.00215143
A0	.00054625	G0	.00320097	M0	.00200423
A1	.00070729	G1	.00326505	M1	.00178343
A2	.00082441	G2	.00330079	M2	.00156263
A3	.00098034	G3	.00331866	M3	.00141543
A4	.00117506	G4	.00333653	M4	.00119774
				M5	.00098684

Figure 5-9. Table of Integral (IF (Tc)) for Various Spectral Types (ST) Green Filter

Spectral Type (ST)	Color Temperature (TC)	Spectral Type (ST)	Color Temperature (TC)	Spectral Type (ST)	Color Temperature (TC)
05	70,000	A5	11,100	G5	5,700
06	61,000	A6	10,500	G6	5,600
07	54,000	A7	10,200	G7	5,500
08	48,000	A8	9,700	G8	5,400
09	42,000	A9	9,400	G9	5,300
B0	38,000	F0	9,000	K0	5,100
B1	34,000	F1	8,600	K1	4,900
B2	31,000	F2	8,300	K2	4,700
B3	28,000	F3	8,100	K3	4,500
B4	25,000	F4	7,800	K4	4,400
B5	23,000	F5	7,500	K5	4,300
B6	21,000	F6	7,300	K6	4,200
B7	19,500	F7	7,100	K7	4,050
B8	18,000	F8	6,900	K8	3,900
B9	16,500	F9	6,700	K9	3,800
A0	15,300	G0	6,500	M0	3,700
A1	14,200	G1	6,300	M1	3,550
A2	13,400	G2	6,100	M2	3,400
A3	12,600	G3	6,000	M3	3,300
A4	11,800	G4	5,900	M4	3,150
				M5	3,000

Figure 5-10. Table of Color Temperatures by Spectral Type

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